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PLANT PROTECTION—THE PROBLEM OF ENTOMOLOGISTS AND PLANT PATHOLOGIST.

FURTHER STUDIES IN TROPICAL LAND TENURE.

LOW TEMPERATURE RESEARCH STATION (1937)

THE PHOSPHATE REQUIREMENT OF CALCAREOUS SOIL.

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PLANT PROTECTION — THE PROBLEM OF ENTOMOLOGIST AND PLANT PATHOLOGIST.

EVER since man began to raise crops, an appreciable portion of his time has been occupied in the problem of protecting them from insect pests and diseases. The geneticist and plant breeder, the soil scientist, the botanist and plant physiologist, the agriculturalist and many others may put their best efforts to producing a new variety of plant and growing it under conditions to give the optimum economic yield, but, should it not be protected from its natural enemies, both animal and vegetable, their work will be at a discount.

Plant protection is very largely the common concern of two economic scientists, the entomologist and the plant pathologist faced with the problem of why plants are dying or why crops have failed, often when it is too late to put ameliorative measures into practice. Symptoms of ill-health exhibited by plants may be due to a variety of causes, among them the attacks of insects and plant pathogens. The damage caused by insects may range from the obvious removal of leaf tissue by a leaf-eating beetle to the injection of a phytotoxin into the plant in the saliva of a sap-sucking insect, such for example as pineapple "wilt", now known to be brought about by the feeding activities of a mealy-bug. The plant pathogen may be a fungus, bacterium or virus, and may cause a bewildering series of symptoms from sudden wilting to a mosaic appearance of the leaf.

The part played by insects in the transmission of diseases in man and other animals has long been recognised by medical and veterinary science. That the important rôle of insects as vectors of plant virus diseases has similarly been realised is seen in the progressive field of virus research. So much cannot yet be said, however, with regard to the fungous and bacterial diseases of plants, although as research advances more and more diseases are being found to be transmitted by insects. It can be predicted that insects will be shown in the future to be the vectors of many plant diseases, in which this method of transmission is unsuspected at the present time. Among fungous diseases already known with certainty to be transmitted by insects may be mentioned the internal boll rot of cotton and Dutch elm

disease. In the former disease the exact relationship between the insect and the fungus is still by no means clear, but it is known that cotton stainers and possibly other bugs are the insects involved. In Dutch elm disease, bark beetles are undoubtedly the principal agents of transmission and, in fact, the disease only exists as such in association with the bark beetles, which are singularly well adapted to serve as vectors. In this case control of the disease is resolved into an attempt to reduce the bark beetle population by the removal of its most favoured breeding places. Bacterial diseases include the "water-mark" disease of the cricket bat willow, a disease peculiar in that the bacteria are restricted to the wood of the tree. A sawfly and a gall midge, which inhabit the wood during a part of their life-cycle, are strongly suspected of being responsible for disease transmission, but this has not yet been proved. A bacterial disease of the olive has been shown to be transmitted by the olive-fly, and in this case it is known with certainty that the bacteria are passed on within the egg from one generation of flies to the next. Vectors of plant diseases are probably to be found among all orders of insects. The aphids are *par excellence* the insects involved in the transmission of virus diseases, and in the few instances cited above sap-sucking bugs, sawflies, gall midges and even bark beetles are involved. Nothing is more certain than, that as more diseases are found to be insect-borne, control measures will be directed, as in the Dutch elm disease and, to borrow an example from medical entomology, human trypanosomiasis, rather against the insect than against the pathogen which itself causes the disease.

All too often the entomologist and the plant pathologist have widely divergent outlooks, and this is felt to be very largely a matter of training. This divergence begins early, for biology, the great life science, has been divided for many years into the two daughter sciences of zoology and botany. Leach (1935) in an interesting review writes of "two young students of biology who start out together but very soon come to the parting of the ways, one to become a zoologist, the other a botanist. After many years of training one becomes an entomologist, the other a plant pathologist, and they meet again both faced with the problem of plant protection. They realise the necessity of co-operative effort and make an attempt to co-operate, but lo! and behold! 'They do not talk the same language'. Their training has been too widely separated and too specialised".

There are very few institutions where the would-be entomologist is given a thorough grounding in the essentials of plant pathology, and the budding plant pathologist introduced to the fundamentals of applied entomology. The entomologist or plant pathologist, particularly if his work should take him to the tropics, is going to be faced with the problem of plant protection when, more often than not, both insects and plant pathogens are responsible for damage at one and the same time. The protection of plants from introduced insect pests and diseases which constitutes a plant quarantine service calls for a close co-operation between the entomologist and plant pathologist if it is to be successful. If the entomologist and plant pathologist have a sound working knowledge of each other's subject and understand and speak "the same language", then co-operation between them is possible and the plant protection problem, whatever it may be, is so much nearer solution. The ideal worker in this field should include in his own mental equipment the outlook and viewpoint of both the entomologist and the plant pathologist.

If plant protection is adequately to be accomplished it is absolutely essential that there should be this closer co-operation between the entomologist and the plant pathologist. A step in the right direction would be the breaking down of what Leach describes as "the narrow professional viewpoint which in effect often hangs out a sign reading: 'This is the phytopathological field; all entomologists keep off' or 'This is the entomological field; phytopathologists encroach at their own risk.'" Should this desirable end be brought about, the future of plant protection would indeed be bright.

Reference.

Leach, J. G., 1935—"Insects in Relation to Plant Diseases." *Botanical Review*, 1, 448-466.

E. Mc C. C.

CACAO SHELL AS FODDER FOR HORSES.

To ascertain the food value of cacao shell used as fodder for horses, draught-horses were divided into two groups and instead of oats, cacao shell was distributed progressively to one of the groups until the ration was doubled. The test was kept up for more than three months, during which time rather heavy work was sometimes done by the animals in the group. The output obtained with the horses fed with cacao shell was not inferior to that obtained with horses fed with oats. No unfavourable influence on the horses' health was noticed with cacao shell. At the time of these tests, it was found that the shell had an assimilable (digestive) albumen content of 2.28 per cent., and a starch value of 41 per cent. Cacao shell is suitable for fodder for adult draught-horses, with the exception of mares with young, and this in quantities up to 3 kg. per day per head, preferably with the addition of molasses and of a substitute to compensate for the smaller contents in albumen. Cacao shell may be used as a substitute for oats if the ration is doubled.—(*Office International du Cacao et du Chocolat*, Vol. VIII, No. 1, p. 6, 1938.)

THE STORAGE OF TROPICAL FRUITS.*

By C. W. Wardlaw.

(*Low Temperature Station, Imperial College of Tropical Agriculture.*)

Of the large number of attractive fruits native to tropical and sub-tropical regions, only a few have yet attained to commercial importance. Relative to citrus and bananas, all other tropical fruits, though their production could be greatly extended, occupy a very minor place on temperate markets and for the most part are only retailed in small quantities and at high prices for the delectation of connoisseurs.

In addition to the tropical fruits occasionally offered on temperate markets there still remains a very considerable number of exotic fruits whose overseas transport has not yet been attempted, or been taken beyond the preliminary experimental stages. For this seeming neglect many reasons can be advanced, including demand (which must first be created by an extensive advertising campaign), competition with other fruits, chiefly temperate, difficulties of consistent production, the need for special packing, shipping and cold storage facilities, and lastly, the high degree of wastage inseparable from the handling of delicate tropical fruits. With a few notable exceptions, in fact, the transport of tropical fruits is still in its infancy. With the improvement of transport facilities it may be anticipated that this situation will to some extent be modified, and that, in time, an increased variety of properly ripened exotic fruits will regularly be offered on temperate markets. Accordingly a wide and interesting field of scientific enquiry still awaits appropriate investigation. Relevant aspects, on which a brief annotation will be attempted here, include (*i*) horticultural relationships, (*ii*) harvesting maturity, (*iii*) pre-storage treatment, (*iv*) cold storage requirements, (*v*) post-storage and ripening treatments and (*vi*) wastage.

1.—Horticultural Relationships.

Environmental factors, seasonal conditions, and plantation sanitation are important in determining quality, keeping quality in storage and wastage (*see* below). The selection of varieties adapted to particular environments, and acceptable on distant markets, is of first importance. Some examples, illustrating these several points may be cited; avocados, which possess a high fat content when grown under dry Californian conditions, have a considerably diminished content when grown under humid conditions in Florida or the West Indies; the Peter's mango, which grows well under Jamaica conditions, cannot be grown commercially in Trinidad because of excessive rotting during storage; the Congo variety of banana, which is cultivated in the French Antilles and can be disposed of to advantage in French markets, is unacceptable on British or American markets.

Standardisation and conservation of desirable types have also important economic aspects. For example, in establishing grapefruit orchards, bud-wood should only be selected from trees, known to possess consistently the desired degree of seedlessness. In fruits such as the papaw in which seedling types show great variability and where no method of vegetative propagation is known, the resulting absence of standardisation is a serious obstacle in the way of developing an export industry.

2.—Harvesting Maturity.

The question of harvesting maturity is specific to each fruit, and criteria, not infrequently of an arbitrary nature, have to be employed. To allow for the progress of ripening during transport and distribution, tropical fruits, as a rule, are picked somewhat immature. Thus the banana is reaped when it is still quite immature and green, at stages described as three-quarters full, heavy three-quarters full, or full, according to the distance of the market for which it is intended. The necessity for harvesting fruits somewhat immature adds to the problems of the physiologist; for whereas in some fruits the onset of ripening is indicated by well marked colour changes, in many others no colour change is apparent, and other means have to be devised in order that fruit shall be harvested at a constant maturity. With grapefruit and oranges, biochemical tests based on the percentage of total solids, and on the ratio of sugar to acid have of necessity been adopted, particularly where early season fruit is being handled. The ratios which have been found suitable in some countries, however, have not always proved rational or acceptable in others, and additional local criteria have had to be devised. In different varieties of mango, it has been found convenient to use a morphological criterion of maturity, the relationship between the stem insertion and the degree of development of the shoulders of the fruit (where growth is localised) being used for this purpose: otherwise, in many of the best commercial varieties, colour changes associated with ripening afford very little assistance indeed. Again, in green varieties of avocado, no good criterion of commercial harvesting maturity, other than a tentative ratio of fat content to the fresh weight, has so far been ascertained. In fruits such as the papaw, to illustrate another aspect of this problem, it has been found that unless fruits show some evidence of yellow (ripening) colour on harvesting, they will not ripen properly later. In tomatoes it is known that fruits picked when they show some pink coloration ripen to a product of superior quality than do those picked full grown but green.

* To be submitted to Section 10, "Storage of Fruit and Vegetables," International Horticultural Congress, Berlin, August 12-20, 1938.

3.—Pre-Storage Treatment.

As a rule, in handling tropical fruits, it is desirable that the time between reaping and placing them in cold storage should be curtailed to the minimum, as it is during the period of exposure to tropical temperatures that wound fungi make a rapid initial penetration which markedly affects the subsequent progress of rotting. Again, in fruits harvested just before the onset of ripening, undue exposure to high temperatures tends to accelerate maturation processes, thereby curtailing the anticipated storage life. While quick handling is usually desirable there are circumstances in which some delay is advisable. Thus with citrus fruits which have been picked in a highly turgid condition, it is sometimes advisable that a quailing or curing period should be allowed to minimise the tendency to superficial bruising and the concomitant fungal wastage.

In some industries, *e.g.* citrus, fruits may be subjected to routine washing, disinfecting, ethylene ripening and machine grading before being packed. Each process requires critical examination in respect of its physiological or pathological effect on the fruit, such problems as desiccation, bruising and wastage being relevant to the case in point. Disinfectant treatments, for example, should only be used when the precise nature of the several rot-producing organisms has been clearly ascertained, since instances are known where the most important pathogens, being already present within the tissue as latent infections, or established as wound infections, are aggravated and not arrested or eliminated by the treatments applied.

4.—Cold Storage.

Although in some instances fruits may be shipped during comparatively long voyages without refrigeration, as a rule, particularly where delicate tropical fruits are concerned, cold storage is essential. Well-equipped refrigerated shipping is in fact the fundamental factor in the overseas transport of perishable tropical produce, refrigeration by the air-blast system being now considered indispensable for the proper handling of fruit. For the major export commodities, such as bananas and citrus, considerable information on the required storage temperatures is now available, but for many others only fragmentary and inconclusive data have been obtained. In selecting a temperature for the overseas transport of fruits two factors are principally involved: (*i*) the temperature must be sufficiently low adequately to control or arrest ripening and the growth of pathogens, but (*ii*) it must not be so low as to cause physiological injury or "chilling" to the fruit. Fruits which have been chilled in transit not only fail to ripen properly, with concomitant loss of flavour, but they are also subject to increased fungal wastage. The onset of chilling, in a number of fruits, is known to coincide with the onset of ripening—a critical phase in the life of fruits. Superficial chilling injury tends to be exaggerated where fruits are also subject to desiccation, whereas at high relative humidities, such injuries may be more or less completely masked. Once the precise storage temperature, *i.e.* just above the critical temperature for chilling, has been ascertained, fruits may be cooled as quickly as possible by delivering cold air at that temperature, without danger of chilling. Where this information is available, pre-cooling may be used to advantage.

The storage temperatures required by different tropical fruits cover a considerable range, which is, however, more in the nature of "cool" storage than "cold" storage. Thus, for fruit grown under West Indian conditions, the following temperatures have been determined: limes, grapefruit and oranges, 45° F.; tomatoes, 45°-47° F.; avocados, 45° F.; mangoes, 47.5° F.; Gros Michel and Dwarf Cavendish bananas, 53° F.; Lacatan, Congo, Giant Governor bananas, 58° F.; papaws, 60° F. In so far as chilling injury is in part a function of the duration of storage, fruits undergoing prolonged storage may require a modification in the upward direction, of the temperatures cited. The tomato may be cited as an example where fruits grown under different conditions may require considerably different storage temperatures. The banana illustrates the fact that different varieties may show considerable differences in their tolerance of low temperatures. The range of temperatures required by different tropical fruits introduces additional difficulties in the matter of shipping, since, as a rule, even modern refrigerated ships are not provided with a number of small compartments in which small consignments can be accommodated each at its own special temperature.

The control of humidity, chiefly the maintenance of high humidities, is also important in the proper handling of fruits grown under moist tropical conditions. Instances are known (*e.g.* limes and grapefruit) where fruit may become unsightly and unmarketable, not because of the onset of fungal wastage, but on account of excessive desiccation. This aspect of the physiology of fruit in storage has so far received insufficient attention: with the advancement of special knowledge of the water-relations of fruit in storage considerable improvement in the technique of handling fruit should become a practical possibility.

5.—Post-Storage and Ripening.

When tropical fruits are removed from cold storage to higher temperatures, ripening takes place rapidly, and serious wastage may soon be sustained. To a considerable extent the latter undesirable feature could be overcome by holding the fruit at a suitable temperature until required for actual consumption. In countries where refrigeration has been more or less thoroughly domesticated, such special post-transport treatment is feasible and is, in fact, a workable proposition. In many countries, however, refrigeration, whether

in warehouses or small stores, is still regarded as an unwarranted and additional expense; until some modification is made in this point of view considerable wastage must be expected during the retailing of delicate tropical fruits. In brief, the outlook for exotic fruits on distant markets will be determined, among other factors, by the extent to which the use of refrigeration becomes domesticated.

Some fruits, in particular the banana, undergo special ripening treatment, involving temperature and humidity control, on being removed from the ships' holds: the improvement of ripening technique opens up a wide and useful field for physiological work.

6.—Wastage.

If tropical fruits are allowed to remain at high temperatures for any considerable time after harvesting, the onset of wastage tends to be rapid. Hence recommendations for the improvement of shipments stress the importance of good organisation to permit of expeditious handling after harvesting and rapid cooling to the approved storage temperature. Wastage in most instances may be attributed to the activities of two major types of pathogenic fungi: (*i*) wound parasites which enter through the numerous wounds and abrasions sustained during handling; and (*ii*) those which are established as latent or dormant infections during the earlier stages of development of the fruit, and which do not become evident until a certain stage in senescence has been reached. Knowledge of the precise behaviour of the several organisms involved is essential in formulating rational measures of disease control. Thus where wastage is due to the development of latent infections, it is evident that control measures must be applied in the field (*i.e.*, by protecting the young fruits from infection), and that questions of environment and plantation sanitation must be given careful consideration.

Summary.

With a few notable exceptions, the overseas transport of tropical fruits is still comparatively undeveloped. The many factors involved in creating an export industry based on the production and handling of delicate fruits notoriously subject to wastage are briefly discussed and illustrated by reference to bananas, citrus, avocados, mangoes and papaws.

THE BIOLOGICAL CONTROL OF THE WEED *CLIDEMIA HIRTA* COMMONLY KNOWN IN FIJI AS "THE CURSE".*

THE history of the introduction and spread of the melostomaceous plant, *Clidemia hirta*, has, so far as the writer has been able to ascertain the facts, already been fully described and a number of reports issued upon the success which has attended the efforts to bring it under control by biological methods. In consequence, the time now seems ripe to review the whole position briefly and to summarise the present state of affairs.

Briefly the plant is supposed to have been accidentally introduced into the Waimanu District of Fiji with coffee plants from Brazil, and certain slight distinctions between the British Guiana, Trinidad and Panama forms of the plant, observed by the writer when carrying out his investigation in those countries, support the view that it came from the mainland of South America. The writer has been unable to ascertain the exact date of the introduction, but it was probably between 1880 and 1886. The plant first began to appear as a low hedge along the wire fences (where the seeds had been dropped by birds) and spread with such alarming rapidity as to acquire the title of the "Curse". It invaded the meadow lands, where cattle would not touch it, and soon covered wide areas to the exclusion of all other vegetation, forming a dense matted growth, four to six feet high, through which the cattle were only able to keep open narrow tracks. It was almost equally at home in such permanent plantations as rubber and coconuts and even invaded the dense native bush. So grave did the position become and so hopeless the task of keeping it in check by hand, that it was even proposed to offer a reward of £5,000 to anyone who would evolve a method of combating it, an offer which was actually made for the control of another pest at that time, *Levuana iridescens*, the purple Coconut moth. When C. H. Knowles was appointed in charge of the Department of Agriculture, he took the matter in hand and when the writer joined in 1919, had already located the home of the weed as Central or South America. In that year reports were received that the plant had had a check in a part of the Waimanu district and the writer was detailed in November 1919 to investigate this check, which, incidentally, proved to be due to nematode worms.

Following on this work the writer forwarded pressed specimens of the plant and paintings of the flowers and seeds to the various Departments of Agriculture in Central America, and to the West Indies, hoping to ascertain the presence of any insect agency likely to assist in checking its ravages. Arising out of these inquiries, F. W. Urich of Trinidad discovered the thrips, which now bears his name, *Liothrips urichi* Karny. He did not, however, place any very high value upon it as a control, and the matter

* Adapted from a paper of the same title by H. W. Simmonds in *Agric. Journ.*, Fiji, Vol. VIII, No. 3, pp. 37-39, 1937.

rested for some time. In 1927 T. H. C. Taylor, who was visiting Trinidad in connection with coconut scale control was instructed to investigate the matter further, and, as a result of this preliminary inquiry, reported favourably upon the action of the insect.

It was then decided to test the insect for undesirable habits, a local student, W. Cook, being detailed for the work. This officer found no bad habits, but expressed a somewhat pessimistic view as to the value of the insect as a control. In view, however, of the seriousness of the weed it was decided that the introduction should be attempted, the writer being instructed to carry out the work, which was commenced in October, 1929. When doing this two important points came out.

(1) That the thrips was itself in Trinidad subject to heavy pressure from a number of previously unsuspected enemies, the elimination of which would enormously increase its efficiency.

(2) That the weed also had many other insect enemies in addition to the thrips, these being chiefly seed destroyers. So that in the event of the thrips proving insufficient, further biological pressure was possible.

The introduction of *Liothrips urichi* into Fiji was successfully accomplished in March 1930, and results have shown that the work of screening out its own enemies was completely performed. The first releases were made at Lami and Nasinu in large solid areas of the weed, and for a little over a year no apparent progress was made. This was partly due to the unfavourable dry weather, but no doubt, scattering has much to do with the apparent failure of the insect to make headway. This scattering, however, led to the formation of numerous small foci, and with the return of normal conditions and succulent growth, the insect began to increase with astounding rapidity, crossing wide areas of sea and jungle (as much as 30 miles of open sea) and everywhere by its attacks on the terminal shoots stunting the weed, which then became overgrown and strangled by competing vegetation. The general effect was that by 1934 large areas of what had been dense curse had been replaced by a mixed growth, much of which was useful vegetation.

There still remained, however, considerable areas of the pest in certain very wet districts, such as Tholo-i-Suva, near Suva, the Tailevu and Salia Levu in Taveuni, and it was not until 1936 when the dry season was again exceptionally sunny and dry that the insect was able to make great headway in these areas, at least in the two former, although even in the Tailevu, where the dairy settlers regularly cut the plant the pressure of the thrips upon the young growth had been sufficient to reduce weeding costs to one quarter.

With the dry season of 1936, however, the pressure of the insect upon the plant in these districts became so severe that at Tholo-i-Suva the competing vegetation was able completely to suppress the big area of old weed and to-day only isolated heavily attacked bushes remain in that district, whilst in the Tailevu the vast sea of *Clidemia* at the end of the settlement is now overgrown, and three quarters dead with good grass opening up in patches. In this area one farmer reported that a hill, which formerly cost him ten pounds a year for clearing had cost him nothing for the past two years.

The thrips can now be said to have accomplished its task. The plant is no longer a curse; hardly a weed, since it is now unable to compete successfully with the other vegetation. The writer is of opinion that a fluctuating balance can now be said to have been established over most of the infected area, isolated bushes sufficient to maintain a thrips population remaining, the number of such varying from year to year. There still remain a few, three quarter dead, stands of the weed. Such remaining areas have yet to be replaced with mixed growth, but the change is taking place rapidly and can always be hastened by cutting. These areas, however, being mostly somewhat unfavourable to the thrips are likely to support a larger normal "curse" population than most portions of the country.

COBALT IN SOILS.

Arising out of the recently discovered importance of cobalt in the control of "bush-sickness" in New Zealand, E. B. Kidson has made a study of the occurrence of the element in soils from various regions of the world. The discovery has also been made in England that "pining" (a disease somewhat like "bush-sickness") is associated with pastures on soils low in cobalt.

The content of cobalt in soils is closely related to the magnesium content of the parent rock material; soils overlying serpentine rocks were very rich in cobalt (300 p.p.m.), whereas those developed from volcanic ash, or from granite were very poor (0 - 4 p.p.m.). Highly leached soils of rubber estates in Malaya, in spite of the presence of lateritic iron concretions, were extremely low in cobalt. A Nigerian Forest Reserve soil profile showed a high cobalt content in an intermediate layer which appears to be related to the alternation of high rainfall and a long dry period with the consequent rise of the products of weathering to a concretionary horizon.

There was little difference in cobalt content between a red soil and a closely-associated black soil from Nyasaland, while a red soil from the same country was higher in cobalt (27 p.p.m.) than a light-coloured badly drained "dambo" soil (16 p.p.m.). A typical "red earth", derived from andesite and until recently under forest in Georgia contained 35, 27 and 62 p.p.m. in the three horizons, A. B. and C respectively. Manuring apparently has little effect on the cobalt content of the soil as judged from continuous manurial plots at Rothamsted and Woburn.—(*Jr. Soc. Chem. Ind.*, 57, 3, p. 95, 1938.)

FURTHER STUDIES IN TROPICAL LAND TENURE.

By H. M. Leake.

(*Continued from Tropical Agriculture*, Vol. XV, No. 7, p. 165.)

II.—THE WEST INDIES.—*Continued.*

Bananas.

For long, the banana crop has formed one of the staple crops of Jamaica, the fruit being bought up by foreign interests. A movement, resulting from a feeling that the intrinsic value of the produce was not realized by the growers, gave rise in 1928 to the organization of the Jamaica Banana Producers' Association which received statutory recognition under the Jamaica Marketing Association Law (5 of 1928). Before that date such control as existed was official under the Produce Protection Law (7 of 1918) and the Fruit Inspection Law (19 of 1926), itself a consolidating Law. This Law was cast in general terms and applied only to scheduled produce. Under it, all dealers and exporters were licenced and authority was taken to appoint inspectors to classify, grade and mark produce while, under an amendment (17 of 1927) these inspectors were authorized to condemn for export, seize and destroy produce. By a further amendment (28 of 1935) registration of contracts was enforced but later bananas were excluded from its provisions by the Banana Industry Regulation Law (24 of 1936) mentioned below.

The above Law (5 of 1928), again, was cast in general terms to include a marketing association for any produce and the power to enter into contracts was given. But the banana undergoes no complex processing; its value depends on the number of hands to the bunch and care is required that the fruit shall be cut at a certain stage of ripeness. Complications of another order, however, enter into its marketing. It is perishable and, to reach the European market, cool storage is required. The unit is, consequently, large, supplies have to be organized and the provision of transport is an expensive item. The subscription of capital to provide this necessary transport offered the main difficulty and this was met by the Jamaica Banana Producers' Association Limited Debenture Law (6 of 1928) which authorized the issue of debentures, guaranteed by general revenues at not greater than 5 per cent. and redeemable in 5 years, a period which was extended by an Extension Law (8 of 1932). Further financial aid was given by a loan of £50,000 authorized under the Jamaica Banana Producers' Association Ltd. Loan Law (25 of 1930), the sum being provided from the Colonial Development Fund for the construction of additional shipping. To meet the special cases of loss from hurricanes, a loan limited to £100,000 was sanctioned by the Banana Industry Aid Law (15 of 1932), supplemented by a further Law (25 of 1933) and again, in more general terms, under the Banana Industry Aid Law (24 of 1935). Finally, the Banana Industry Regulation Law (24 of 1936) consolidated the regulation in all its branches. It is unnecessary to follow the history of the Association in detail; it has suffered from many teething troubles but has weathered them all in spite of the economic blizzard and natural hurricanes and, as early as 1931, it was reported that it was really due to the banana industry that Jamaica had not experienced an even more drastic depression.*

But other islands, in their search for alternative crops, have turned their attention to bananas and this has been rendered possible by the establishment of the Canadian National Steamship Service, established in 1929. In Trinidad, following trial shipments to Canada under a Government grant, the Banana (Control) Ordinance (7 of 1934) established a Control Board with the Director of Agriculture as Chairman and Officers of the Department providing the administration, limited exports to the Board and authorized advances from public monies. In Dominica a Banana Ordinance (2 of 1934) was passed establishing a Dominica Banana Association with an export monopoly and Ordinances of the same tenor were passed in St. Vincent (4 of 1934) and St. Lucia (1 of 1934).

Citrus.

Jamaica was the only island which, until recently, exported citrus fruit other than limes and lime products in significant amounts. In the past few years the cultivation of oranges and grape fruit has been extended in several other islands, especially those lying on the route of the Canadian Service. Citrus fruit has to meet a market accustomed to supplies from the highly organized industries of California, Palestine and South Africa. It must be free from blemish, graded and packed in standard crates and these conditions have to be met under a system of production involving a large number of unorganized growers. Jamaica, with its old established industry, followed the lines adopted in the case of the banana and formed a Citrus Growers' Association in 1929. Control was exercised under the Agricultural Produce Law (19 of 1926) licensing premises for grading, marking and packing, registering trade marks and appointing inspectors. In 1935 special aid was given to the citrus industry under the Citrus Development Aid Law (31 of 1935) which authorized a Citrus Development Board of three members, sanctioned a grant of £7,500, organized supplies of young stock under the direction of the Board and placed control of cultivation under the Director of Agriculture.

In Trinidad citrus cultivation for export is a comparatively new industry and is organized under the Sale of Produce Ordinance (26 of 1932),

* Colonial Reports, 1603 (1931).

which amended the original Ordinance of that title (54 of 1921), and specifically mentions citrus fruits but includes coffee, nutmegs, kola nuts, tonka beans and rubber. The organization for export is controlled by a Citrus Growers' Association established in 1930. Of the smaller islands St. Lucia passed the Fruit Exportation Ordinances (1 and 17 of 1933) amending the original Ordinance (12 of 1930) under which all fruit for export is graded, marked and packed in standard packages. Similar Ordinances were passed in Grenada (22 of 1930), Dominica (4 of 1928) and Montserrat (5 of 1928). All these latter either established Government packing stations at which fruit for export was examined and/or licensed premises for the same purpose. They are also of a general nature and include all fruits including tomatoes.

Cotton.

The commercial cultivation of cotton is practically confined to certain of the Windward and Leeward groups of islands and Barbados. In the more northerly of these it is a crop which plays a large part in their economy. The kind grown is Sea Island of the production of which these islands have a practical monopoly since 1918 when the American crop was wiped out by the boll weevil. Since the end of the war the industry has suffered from depression due mainly to the limited market for a cotton which is of outstanding quality and dependent for its market on the demand for only the finest class of cotton goods. While the problem, thus, primarily concerns the market, the agricultural aspects are not unimportant. These latter offer two major problems. Owing to the fact that cotton is an annual raised from seed while cross-fertilization is common, special precautions in the matter of seed supply have to be taken to ensure maintenance of a purity which is essential to quality. Again, it is a crop which is singularly susceptible to pests, particularly boll worm and cotton stainer, and these require to be controlled. The system under which it is cultivated in those islands where it plays a dominant part have been described by Sampson ;* it is both a peasant crop and grown on estates and the precautions which have to be taken involve a large number of independent and, in many cases, small units of production. As the case with cotton in so many parts of the world, the commercial crop covers a mixture of types and the work in St. Vincent and at the Empire Cotton Growing Corporation's Station in Trinidad has done much to secure purity of type and the introduction of these new types under conditions which would maintain purity has offered further problems of a practical nature.

Independent attempts to control the cotton industry to meet these difficulties have been made in many islands. Thus, in St. Vincent, the Agricultural Produce Protection Ordinance (11 of 1906) with frequent amendments, besides referring to arrowroot, cocoa, nutmegs and mace, specifically dealt with cotton by the now well known method of licensing dealers and appointing inspectors for the growing crops and ginneries. It also compelled the registration of the location of the crops by growers. The Cotton Protection Ordinance (6 of 1924) gave wide powers to inspectors, imposed a close season and the fumigation of seed for sowing, laid down rules for the disposal of extra seed and seed products and sanctioned steps to eradicate the cotton stainer. The Cotton Seed Control Ordinance (26 of 1933), placed the control of cotton seed directly under the Director of Agriculture and authorized him to enter fields for the purpose of roguing the crop.

In Antigua steps were early taken for, in 1865 a Cotton Protection Ordinance (239 of 1865) was passed only to be repealed and replaced by a similar Ordinance (24 of 1867) which was in force till 1892. In 1922 an Ordinance of the same title (7 of 1922) with its amending Ordinance (14 of 1929) was passed. The trade in cotton was controlled by the Cotton Traffic Ordinance (5 of 1906) which licensed dealers, enforced a close season and ordered registration of areas and location of fields. In 1919 the Cotton Stainer Ordinance (8 of 1919) appointed inspectors to take approved steps against stainers while the Cotton (Close Season) Ordinance (10 of 1919) imposed a close season. This spate of Ordinances continued with the Cotton Planting Ordinance (1 of 1931) and the Cotton Seed Control Ordinance (10 of 1932) of which the titles adequately indicate their import.

It would be wearying to follow in detail the similar series of Ordinances in the other islands, Grenada, Montserrat, St. Kitts, the Virgin Islands and Barbados, though, in the last of these, the Cotton Diseases Prevention Ordinance (1 of 1928) and its amendment (34 of 1929) imposed a close season for okra and other alternate hosts of the boll worm. Each island in varying degrees has attempted to control and protect the cotton crop. But their efforts were uncoordinated and it took the depression of the early thirties to bring about coordination. As the result of conferences conducted in 1933, a West Indian Cotton Growers' Association was formed with branches in each island. These branches absorbed the local Growers' Associations the earliest of which was that formed in St. Kitts in 1916. A history of this movement and its objectives is given in *Tropical Agriculture**. This coordination received expression in the Cotton Export Ordinance (20 of 1934) in Antigua and similar Ordinances in St. Kitts (13 of 1935) and Barbados (35 of 1935) the latter of which was followed by a Cotton Growers' Association Ordinance (16 of 1936). The major objective of these Associations is marketing ; the control of the agricultural side remains largely a matter of official control. Thus in Grenada, the Carriacou Cotton Replacement Ordinance (15 of 1934) arranged for the destruction of all seed and the subsequent sowing of such seed only as was approved by the Department of Agriculture. In Montserrat the Cotton Seed

* *Empire Marketing Board, Rept.* 5 (1927).

* *Tropical Agriculture* 11 (1934), p. 1.

Control Ordinance (11 of 1936) and a similar Ordinance in St. Kitts (4 of 1936) laid down very detailed control by the Department of Agriculture.

Coconuts.

The main product of the coco palm, copra, is exported from the littoral areas of practically all tropical islands and countries having a seaboard. There is, therefore, no monopoly and there arises the question of quality which is dependent on the method of preparation. On the agricultural side, the tree takes several years to come into bearing and it is mainly cultivated on an estate basis. Copra is valued for its oil content and, in the larger West Indian islands the local market is capable of absorbing supplies extracted locally.

The earliest control in Jamaica was introduced by the Agricultural Produce Law (19 of 1926), which included copra with citrus and bananas as requiring for export to be graded and marked and to bear a registered trade mark. Following the lead of the banana producers, the Jamaica coconut planters organized a Jamaica Coconut Producers' Association registered as a limited Company in 1931 and, in the same year, debentures were issued under the Jamaica Coconut Producers' Association Ltd. Debenture Law (22 of 1931) with a Government guarantee while the industry was controlled by the Coconut Industry Aid Law (23 of 1931) which established a Coconut Producers' Board, licensed imports, controlled exports, fixed maximum retail prices, imposed a duty (with Empire preference) not exceeding 6/9 per gallon edible oil and an excise of 9*d.* and licensed manufacturers of coconut products.

In British Guiana a Copra Products (Sale and Manufacture) Ordinance (31 of 1933) of similar tenor was passed. Manufacturers and brokers were licensed and the latter alone permitted to sell to manufacturers and to export, a duty imposed on copra products, and the fixation of wholesale and retail prices for copra products, of standards of quality for these and of a minimum price for copra charged to the Governor in Council This Ordinance was modified in detail by an amending Ordinance (23 of 1934) and the Copra Products (Control) Ordinance (36 of 1935). In Trinidad the Copra Products (Control) Ordinance (1 of 1932) follows the same lines with its amending Ordinances (11 of 1933 and 4 of 1934).

The major objective of these Laws and Ordinances was to establish a local industry for copra products. In the smaller islands there was too little scope for a local oil extraction plant and control is confined to licensing dealers; in Grenada by the Sale of Produce Ordinance (9 of 1933), in Antigua and Dominica by inclusion of copra in the list of products scheduled under the respective Agricultural Produce Protection Ordinances (14 of 1913 and 8 of 1905).

Rice.

Paddy is cultivated in those colonies where an East Indian community has established itself. In the case of British Guiana alone, however, has a regular export trade been developed. Though a grain, paddy is generally hulled and, in the case of supplies for an East Indian market, parboiled. These preparatory processes complicate the question of meeting competition from the East. The problems have been discussed by Douglas.* The potentialities of an export market developed during the war but control was first introduced by the Rice (Export Grading) Ordinance (18 of 1930) and its amending Ordinance (40 of 1932) which imposed a system of grading and blending under the agency of the Director of Agriculture. The Rice (Export Trade) Ordinance (47 of 1932) imposed export licences to be granted by a Board which included the President of the Chamber of Commerce, the Manager of Barclays Bank D.C.O. and six members and weekly prices were fixed by the Board. This was a temporary measure continuing in force till 1934 when it was repealed by the permanent Rice (Export Trade) Ordinance (17 of 1934) which established a British Guiana Rice Marketing Board as a corporate body composed of officials and nominees of the Governor in Council with an Advisory Committee chosen by the Governor in Council with functions as laid down in the temporary Ordinance. Further control was imposed by the Rice Factories' Ordinance which licensed factories mainly to control the sanitary conditions under which human food was to be produced.

Minor Products.

Many of the above Ordinances and Laws are of a general nature and apply the licensing of dealers to a range of specified products. Two products only require special mention. In 1930 a Cooperative Pimento Association was formed in Jamaica following the general lines of such Associations. In St. Vincent a St. Vincent Cooperative Arrowroot Association was formed under the St. Vincent Arrowroot Ordinance (15 of 1930), to handle the crop peculiar to that island. The Association was given the monopoly of export while membership was open to producers and/or dealers in 50 barrels. The St. Vincent Cooperative Arrowroot Association Loan Ordinance (2 of 1931) authorized a loan of £30,000 free of interest for a period of five years, the sum being advanced from the Colonial Development Fund. In most of the smaller islands Government Fruit and Produce Depôts have been opened to bulk, grade, pack and export minor fruits and produce.

General Agricultural Aspects.

The preceding account deals with the various crops the produce of which feeds an export market. It gives in outline the means which have been adopted to make the several products acceptable to those markets; particularly in the matter of quality. The basic problem here is the organization of supplies from units ranging from estates to small peasants' holdings, which the system of tenure has allowed to develop, into that steady stream of graded produce which is essential if it is to be accepted by the somewhat critical

* *Empire Marketing Board, Report*, 32 (1930).

markets of to-day. These means barely touch the primary problems which are essentially agricultural. The development of the higher standards of cultivation here implied is a function of the Agricultural Departments but these higher standards nearly always involve increased expenditure and, where a poor peasantry forms a large section of the producers, it is as useless to recommend such measures as to expose expensive goods for sale in a slum neighbourhood.

The primary essential here is to provide the finance which will make that higher standard attainable. The solution of that problem is the major function of the Cooperative Movement which has been inaugurated in practically all the West Indian Colonies. The movement was slow to crystallize out and was preceded by earlier endeavours less clearly directed to this objective. In Jamaica an Agricultural Loans Law was passed in 1887 and, later, in 1912, an Agricultural Loan Societies Law established a Board to loan to Agricultural Societies registered under the Industrial and Provident Societies' Law (33 of 1902) while the Agricultural Societies' (Special Loans) Law (16 of 1936) authorized Government loans through the Board to any agricultural industry suffering material damage. In British Guiana an Agricultural Relief Ordinance (20 of 1896) facilitated loans against crops by arranging for registration but a true co-operative movement was started by the Cooperative Credit Ordinance (9 of 1914) which was revised by the Cooperative Credit Banks Ordinance (28 of 1933) establishing a Board with the Director of Agriculture as Chairman. By 1932 there were 27 banks with an approximate membership of 11,000 and a share capital of some $83,000. The movement was started by the Cooperative Credit Societies Ordinance (30 of 1915) in Trinidad, in Barbados by the Agricultural Credit Act (1 of 1924), in St. Vincent by the Agricultural Credit Ordinance (12 of 1924) repealed by the Agricultural Credit Societies Ordinance (1 of 1934) and in St. Lucia by the Agricultural Credit Societies' Ordinance (7 of 1915).

More directly concerned with agricultural practice are the steps taken to preserve the crops free from pests and diseases. Some of these date from early in the present century, as the Agricultural Interests Protection Ordinance (17 of 1900), and it would be wearying to list the numerous Ordinances dealing with this subject. They all have a common basis of control of imported living material, insistence of a duty to report such pests and diseases as may be notified and powers to an inspectorate to take the necessary steps to control, the administrative authority being the Department of Agriculture. Special legislation has been taken in the case of cotton in several islands as noted above and, in Barbados, the Mosaic Disease Eradication Acts (39 of 1921 and 23 of 1927) deal with this specific disease of sugar cane.

Land Settlement.

There is one residual problem concerning tenure left for consideration; it is that which arises from that primary function of Government, the assurance of adequate supplies of the food of the people. Essentially this is a question of the production of what are known as maintenance cultures. In countries like the West Indies with equable climates, failure of food supplies as the result of drought is unknown though temporary shortage may occur as the result of hurricanes. The problem is, consequently, not so much the guaranteeing of supplies as of ensuring that the peoples have the wherewithal to purchase or produce them. To a large extent many of the islands are worlds in miniature especially when, as now is the case, the safety valve of emigration is no longer freely open. One of the reactions to the recent slump has been an enforced economy which has thrown out of employment a large body of labour which has no alternative means of subsistence. It now becomes a case less of providing the means for an improving standard of living than of ensuring to all the primary essentials of life, though the two merge into each other.

The primary industry of all the West Indian Colonies is agriculture and the mass of the population is but a short distance removed from the land; even such industrial labour as exists has an agricultural background. Under these conditions the most obvious form of relief is to settle the idle population on the land so that it may provide the major portion at least of the food it requires. This is the procedure that has been widely adopted. In Jamaica, where the problem has been accentuated by the repatriation of numbers of emigrants to Cuba, a policy of buying up estates for the development of land-settlement schemes has been followed and, in 1930, over 2,000 such repatriated persons were settled on two estates totalling 3,550 acres at a cost of £12,500. In Trinidad and Antigua Crown Lands were available and, in the latter island, definite settlement schemes were undertaken, the purchase price being £4 to £10 per acre and the cultivation placed under the control of the Agricultural Department. In St. Vincent settlement had been practised for many years under Land Settlement Ordinances (2 of 1899, 17 of 1915 and 7 of 1917), presumably as the result of the recommendations of the West Indian Royal Commission of 1897, but, in 1933, settlement was restarted on land purchased with a loan sanctioned by the Land Settlement Loan Ordinance (12 of 1932). St. Kitts and Grenada saw schemes underway in 1931 and 1934 respectively with loans provided from the Colonial Development Fund while, in Dominica, an estate was purchased for fruit on a Land Settlement basis. In many cases, these schemes are linked up with Government provided fruit and produce depôts, in some cases packing and grading produce for export, in others organizing supplies to the local market. Thus, in Trinidad a Ground Provision Depôt had been established for some years and this was placed on a more secure basis by the Trinidad and Tobago Ground Provision Depôt Ordinance (33 of 1935).

(*To be continued.*)

THE LOW TEMPERATURE RESEARCH STATION (1937).

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Introduction.

As constructed in 1928, the Low Temperature Research Station, Fig. 1, at the Imperial College of Tropical Agriculture was specifically designed for work on the experimental bulk storage of bananas, this being necessitated by the need (*a*) for improving storage technique as applied to the Gros Michel—the major commercial variety—and (*b*) for investigating the storage behaviour of other varieties and hybrids which might be used as substitutes for the Gros Michel in the event of that variety being eliminated by the epidemic spread of Panama Disease.

Empirical bulk storage trials with bananas being the special object for which the Station was designed, the layout and equipment to a large extent were based on the system which had been found efficacious on the better equipped "banana boats" of that period, *i.e.* provision was made for rapid cooling of consignments by air-blast refrigeration.

The construction and equipment were described by McGuire (2). The building was erected and equipped at a cost of approximately £5,800, funds being provided by the Empire Marketing Board. It consisted essentially of an engine room, a small physiological laboratory, an air lock (1,900 cubic feet), and four storage chambers; three of these had a capacity of 1,130 cubic feet and the fourth, which was considerably larger (2,340 cubic feet) served as a ripening room. The refrigerating plant, Fig. 2, consisted of two J. and E. Hall's vertical, No. 6 size, ammonia compressors, five inches bore by six inches stroke, direct-coupled to two 8½ B.H.P. repulsion induction type motors, the compressors running a 220 r.p.m. and the motors at 1,165 r.p.m., the electrical equipment being 60 cycle, 440 volts. The two oval coil atmospheric condensers, consisting of 265 feet of one and a half inches bore pipe, were cooled by a centrifugal circulating pump capable of delivering about 50 gallons of water per minute. The brine tank, in which were two evaporator coils of 275 feet each, of one inch bore pipe, measured ten feet by four feet six inches by four feet six inches, and the cold brine was circulated through the air cooler coils by two centrifugal pumps each capable of delivering 30 gallons of brine per minute. One pump was capable of dealing with the whole installation, the second being kept in reserve. The air-coolers, whereby the chambers were refrigerated, consisted of 350 feet of one inch bore piping in the case of the larger ripening chamber, and 175 feet of similar piping for each of the smaller storage chambers. The fans delivered air at the rate of 2,500 cubic feet per minute in the case of the large chamber and 1,200 cubic feet for the smaller ones. They were of the centrifugal cased type, with full housings and flanged suctions and discharges. They were fitted with dampers of the sliding type, and were direct-coupled to electric motors. The air lock was cooled with 250 feet of one and a half inches bore brine grids, which were carried from the ceiling and were fitted with Fibro-cement drip trays. The floors were protected with cork slabs laid in two thicknesses, and the chamber walls and ceilings were covered with six inches of granular cork, and were double boarded. Each chamber was fitted on both the delivery and the suction sides with an electric long distance thermometer, whereby the temperatures could be read in the engine room. The 1928 equipment also included an ice-making tank and small provision room. Fig. 3 shows a ground floor plan of the Station as originally constructed. Further details concerning the Station have also been published by Leonard (1).

Within a few years the very general use to which the Station could be put was recognised by shipping companies and by the local agricultural administrations in the Caribbean area, and, by request, work was extended in turn to tomatoes, limes, grapefruit, oranges, avocados, mangoes, papaws, egg-plant fruits, cucurbits of several kinds, and to the assortment of vegetables that can be grown in the tropics. To some of these commodities a considerable amount of time has been devoted and it may be said that their general cold storage requirements have now been ascertained with a sufficient degree of precision for practical purposes. The temperatures which have been adopted for the transport of fruits and vegetables grown in the Caribbean region are in fact, in several instances, a direct result of these investigations.

As work on the several commodities progressed, the limitations of the Station, as originally designed, became apparent, including the need for maintaining higher humidities and for humidity control, greater elasticity in respect of temperature, (in particular, provision for lower temperatures) and additional laboratory accommodation and equipment to make possible the pursuit of

fundamental research on the physiology of fruit in storage. To these ends, reconstruction was undertaken during 1936-37, based on grants, amounting to £4,625, provided by the Colonial Development Fund.

Some of the major changes effected are described below. At a later stage it is hoped to issue a sequel to the present paper, in which the detailed functioning of the Station in terms of physical measurement will be set forth.

New Laboratories.

The original Station, while adequately equipped for cold storage trials, was quite unequipped in respect of laboratory accommodation, only a small room being available. In the new construction accordingly, special attention has been given to providing additional laboratory space and facilities for the pursuit of biochemical and physiological studies. Reference to the plans (Figs. 3 and 4) and to Figs. 1, 5 and 6 will show how this has been accomplished. On the ground floor are three small preparation rooms, and the main biochemical laboratory, equipped with the usual services. Leading off the biochemical laboratory are a cloak room, balance room and store. Direct access to the cold storage rooms is also permitted by an insulated door. As far as possible, the construction is such as to permit of shutting off the preparation rooms (from which fumes might be discharged) from the storage space.

The southern preparation room admitting to the air locks, is used for fruit examination and for Pettenkoffer titrations; the central room accommodates water-baths, distillation apparatus, &c., and the northern room serves as a mycological preparation room.

The upstairs laboratory is used for physiological and anatomical work. It also includes two private rooms, and gives access to the trunk room above the storage rooms. In this, as in the other laboratory space, the furnishings have been selected and installed so as to be capable of modification to meet the needs of future developments.

Storage Rooms.

No increase has been made in the total capacity of the original insulated space, but by effecting the subdivisions shown in Fig. 4, six storage rooms have been provided in place of the original four (Fig. 3). This caters for such bulk storage trials as may be found necessary, any of the rooms being adaptable to this purpose, but it also leaves additional rooms free for special experiments running concurrently with bulk storage trials, it being undesirable to attempt both in one room.

It will be observed that whereas rooms 2 and 3 (Fig. 3) *i.e.* 3 and 4 (Fig. 4), remain unchanged, it was possible by curtailing the air lock at the northern end to provide one room of about the size of Nos. 3 and 4, and one small additional storage room. Again, by dividing the original No. 1 room, designed as a ripening room, two rooms of adequate size have been obtained. It will be seen that, with minimum new construction, useful alterations of the original storage space have been achieved.

Fig. 7 shows the interior of room No. 2 with a respiration experiment in progress.

Insulation.

The original fabric consisted of 6-inch reinforced concrete walls, and granular cork insulation, 6-inch on the external walls of rooms, 4-inch walls between rooms, and 4-inch on the air lock walls, faced with a double layer of ¾-inch highly varnished white pine.

Repairs necessitated by more or less extensive dry rotting in the white pine, and spreading to the framework, had to be undertaken on several occasions during the first five years. Replacements were made using well-cured cypre (*Cordia alliodora*, a local timber roughly described as the Trinidad domestic equivalent of oak). This wood has, in fact, stood up well to the variable conditions in the storage rooms.

During the reconstructional work, the opportunity was taken to increase the thickness of insulation of external walls by 2 inches of granular cork; the original insulation was supplied for room temperatures of 53°F., but this, on collective experience, was considered inadequate for the new programme of work. As in replacement work, cypre has been used for finishing, except in rooms 5 and 6 where a hard cement and paint finish has been applied. The screens carrying the air-ports are set at 9 inches from the end walls and are removable. Brackets for holding the recording instruments have been fixed at eye level in each of the rooms, Fig 7.

Air Ducts.

Cooling, as before, is effected by the battery (air-blast) system, the original longitudinal, wall to wall delivery being continued. The air ducts and coolers are accommodated in a trunk room, already mentioned, directly above the cold storage rooms. Each room has its own separate trunk, and air is circulated continuously through a duct of varnished wood. In each trunk there are the following units, proceeding from the return (*i.e.* suction) to the delivery side: (*a*) a Sirocco centrifugal fan (11 inches for Rooms 3, 4, 5, 6 and 12 inches for Rooms 1 and 2) coupled to (*b*) a cylindrical air cooler; (*c*) electrical heater mats, operating in conjunction with (*d*) a mercury-in-glass thermostat (*see* Figs. 9 and 10).

In the original construction, the trunks were built so that each cooler rested on the floor, above the insulated ceiling of its respective storage room, Fig. 8. It was found that rotting was always most severe on the fan side of the cooler. To avoid this undesirable feature, and to permit of inspection of drainage pipes and fabric, the trunks in the new construction were raised so that a six inch space was left between trunk and floor, Figs. 9 and 10. This arrangement also facilitates the run-off of condensation water from the cooler casing.

Photo by *Tucker Pictures Production Ltd.*

FIG. 1.—The Low Temperature Research Station as constructed in 1928, showing atmospheric condensers on left.

Photo by *Tucker Pictures Production Ltd.*

FIG. 2.—General view of engine room, as constructed in 1928, showing the two compressors, the ammonia expansion and return valves, and the brine tank (bottom, left).

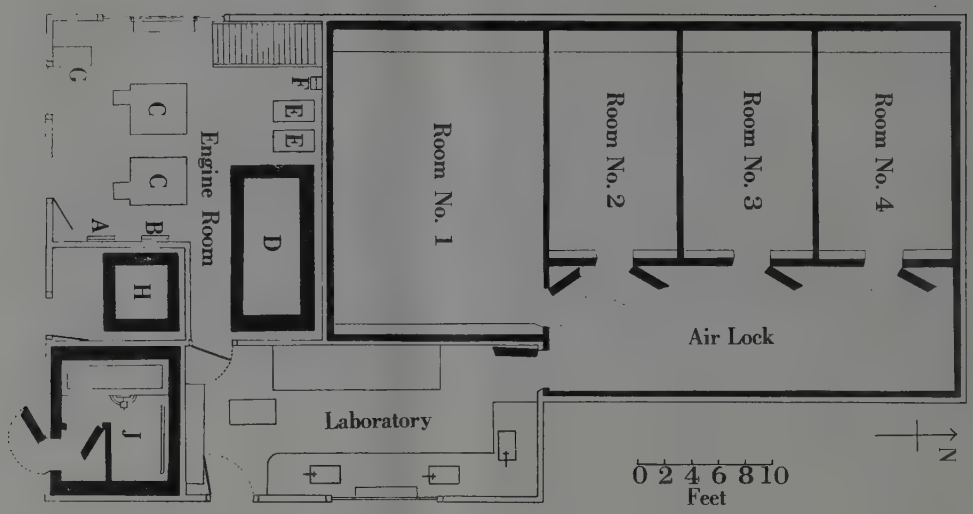

FIG. 3.—Ground floor plan of the Low Temperature Research Station as constructed in 1928. A, ammonia expansion valves; B, ammonia return valves; C, compressors; D, brine tank; E, brine pumps; F, long distance thermometers; G, condenser water-pump; H, ice-making tank; J, provision room with direct-expansion coils and brine stabilising tank.

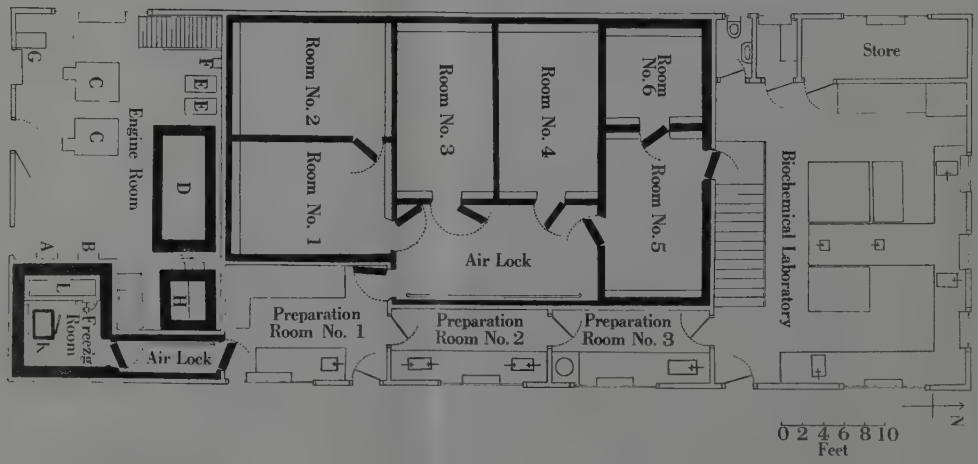

FIG. 4.—Ground floor plan of the Low Temperature Research Station as reconstructed in 1936-37. A, ammonia expansion valves; B, ammonia return valves; C, compressors; D, brine tank; E brine pumps; F, long distance thermometers; G, condenser water-pump; H, divided brine tank; J, brine pumps,; K, freezing cabinet; L, brine tank.

Photo by *Tucker Pictures Production Ltd.*

FIG. 5.—The Low Temperature Research Station as extended in 1936-37 (from S.E.). On the left are the atmospheric condensers with an asbestos roof. The two-storey addition on the right accommodates the bio-chemical and physiological laboratories (*see* Fig. 6).

Photo by *Tucker Pictures Production Ltd.*

FIG. 6.—New Laboratories as seen from the north-east.

Photo by *Tucker Pictures Production Ltd.*

FIG. 7.—View inside No. 2 Room showing the delivery air ports, the long distance thermometer on ceiling, and the suction and fresh air delivery lines for use in respiration experiments; also hygrostat, recording instruments, and a banana respiration experiment in progress.

Photo by *Tucker Pictures Production Ltd.*

FIG. 8.—Air trunks or ducts, above storage rooms as originally constructed; as the floor constituted the base of the duct no inspection of the fabric under the cooler was possible (*compare* Fig. 9).

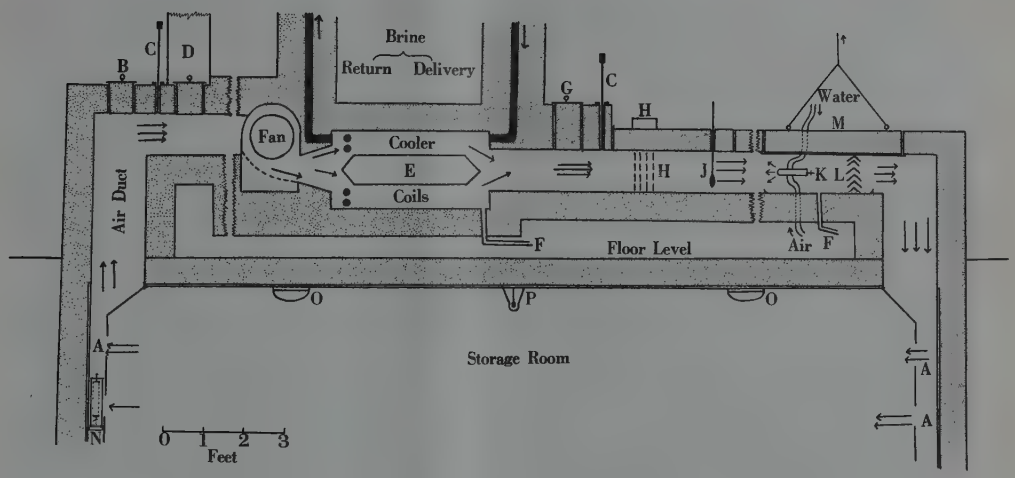

FIG. 9.—Diagram (to scale) showing the principal structural features of No. 2 Room air ducts in vertical section. It will be noted that the entire cooling and humidifying units are raised above floor level, thereby permitting of inspection of the drainage pipes and insulating fabric. A, delivery and return air ports in storage room; B, foul air vent and plug; C, baffles; D, fresh air inlet trunk, vent, and plug; E, air deflector in cooler; F, drainage pipes from cooler casing and humidifier pan; G, defrosting vent and plug; H, heater mat unit; J, mercury-in-glass thermostat; K, humidifier spray-jet, supplied with water from above and with compressed air from below; L, eliminator; M, humidifier inspection trap and insulated plug operated by counterpoise weight; N, hygrostat; O, bulk-head lights; P, long distance thermometer.

Photo by *Tucker Pictures Production Ltd.*

FIG. 10.—View of trunk room, showing (middle left) the delivery end of a duct with middle portion, *i.e.* housing heater mats, cooler, &c., raised off the floor. This photograph also shows brine pipe casing (top centre) and air compressor for humidifier (bottom right, front) and vacuum pump (behind).

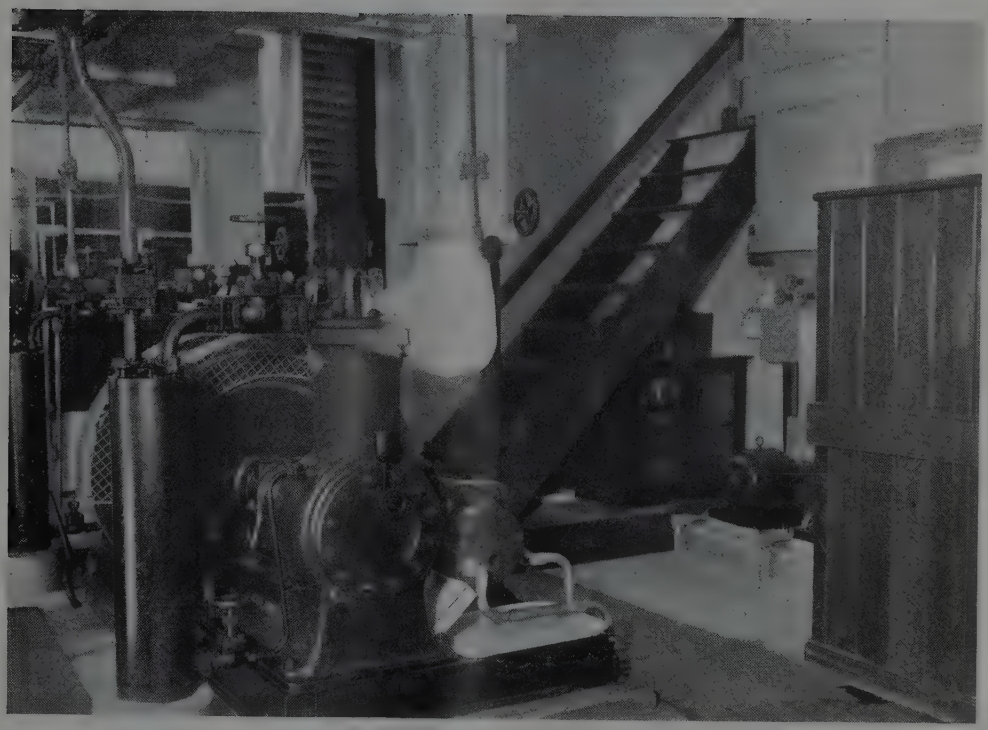

Photo by *Tucker Pictures Production Ltd.*

FIG. 11.—View of engine room, showing the two compressors (left), a brine pump motor and brine delivery header (right, centre) and large brine tank (right). The stair leads up to the trunk room.

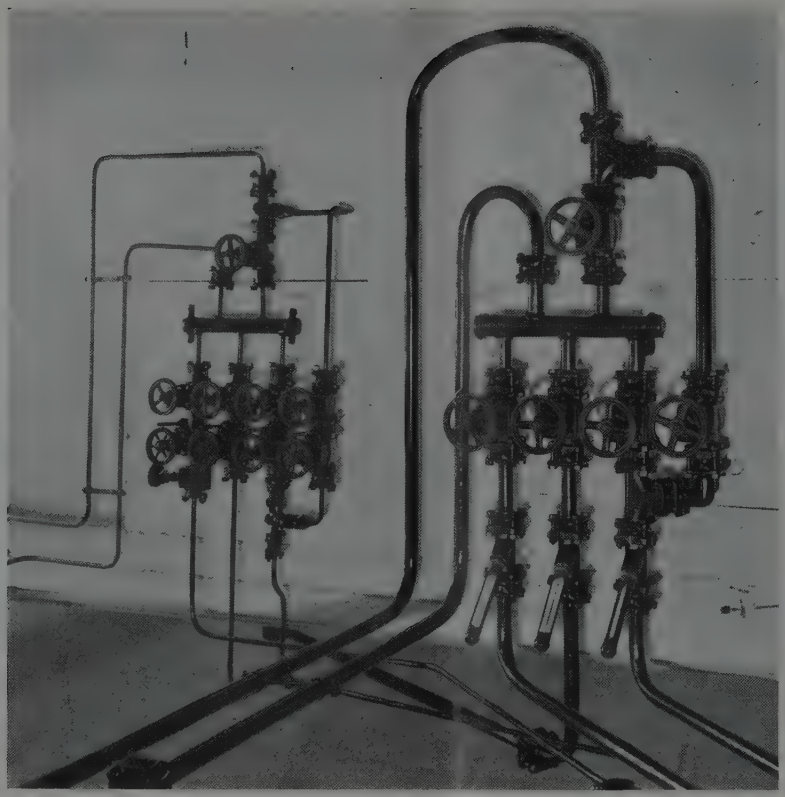

Photo by *Tucker Pictures Production Ltd.*

FIG. 12.—Ammonia expansion (right) and return (left) valves, showing the circuit by-pass arrangements. The photograph was taken prior to the application of the slab-cork insulation.

The insulation of the trunks has also been increased to a minimum of 8 inches of granular cork. Each trunk is also provided with (*i*) a foul air vent separated by a baffle from (*ii*) the fresh air intake during blowing out operations; and (*iii*) a defrosting vent immediately after the cooler on the delivery side. The fresh air intakes are trunked together and are led outside to a N.E. exposure.

Special Features of Individual Rooms.

Some special features of the different rooms may now be noted. The coolers in Rooms 3, 5 and 6 are the three small coolers originally installed, *i.e.* consisting of 175 feet of 1-inch bore piping. In passing it may be noted that in providing the small room (No. 6) with a cooler of this size, the proportion of cooler to cubic capacity of room was considerably increased. In No. 4 Room the new cooler is larger and consists of an inner series of coils of the same dimensions as those supplied to Nos. 3, 5 and 6, and also an outer layer, giving an additional 90 ft. of cooling coil. The two sections of coil are independently supplied with brine. Rooms 3 to 6 are operated from one common brine tank. Rooms Nos. 1 and 2 are provided with relatively large coolers, consisting of 350 feet of 1-inch bore piping, each cooler being supplied with brine from its own tank (*see below*). Nos. 1 and 2 have variable fan speed achieved by means of stepped pulleys, whereby fan speed may be reduced to 50 or 25 per cent. as required.

The special feature of No. 2 Room is the installation of humidifying apparatus (Figs. 9, 10). This consists of an aerograph spray-jet, projecting into the trunk on the delivery side of the heater-mat; it operates by discharging a fine spray of water into the on-coming air by which it is partly taken up. The spray-jet is operated by an air-compressor, water being supplied from an overhead tank (with ball-cock). The compressor is driven by an electric motor which is controlled by a hygrostat, mounted inside the room (Fig. 7).* Particulate water is eliminated from the delivery air by means of a system of copper louvres. A sheet of plate glass over that portion of the trunk in which the spray nozzle is situated, permits of inspection of the vaporising jet. The glass is normally covered by an insulated plug operated by a counterpoise weight. The trunk in the vicinity of the spray-jet is lined with copper sheeting and a drainage pipe is supplied.

Suction Line.

A suction line, for use in physiological experiments, is supplied to each storage room and also to the main laboratories, suction being supplied by a Reavell pump, Fig. 10. The control of suction is by needle valves. Fresh air delivery pipes are also installed side by side with the suction line, Fig. 7.

* Experience showed that better results were obtained when the hygrostat was installed in the return air trunk, as shown in Fig. 9.

Freezing Room.

A special freezing room, to facilitate biochemical work and to eliminate, as far as possible, changes in chemical composition during sampling, has also been included as an integral part of the reconstructed station, Fig. 4. It occupies the site of the former provision room, Fig. 3, but is provided with its own air lock, cooled by a wall brine grid, and is entered from Preparation Room No. 1.

As very low temperatures were required in the freezing room, special attention was paid to insulation. The concrete walls were lined with a proprietary bituminous sheeting, sealed at the overlaps and joints. Granular cork was then applied to a thickness of 12 inches, the room being finished with cypre boarding as already described.

Cooling of the room is effected by means of direct expansion grids, one on the wall, one immersed in a brine tank to afford more stabilised temperatures, and a third grid which serves as a base on which the freezing box rests. Air circulation is by means of a fan set high on one wall and provided with screens to permit of satisfactory air distribution.

A special insulated freezing cabinet, in which the three shelf supports consist of direct expansion coils, has been installed for the rapid freezing of tissues. In practice, a temperature of 0-10°F. and -20°F. to −30°F. can be obtained in the room and freezing cabinet respectively. The arrangement of the valves within the room is such that the several cooling units can be brought into use or isolated as required.

The Engine Room.

The compressors in use are those originally installed in 1928 and are as described in the Introduction (*see* Figs. 2, 11). The original atmospheric condensers had to be scrapped because of excessive pitting corrosion, and have been replaced by similar units with galvanised finish. A corrugated asbestos roof has been erected to minimise direct heating by the sun (Fig. 5).

In all, three cooling units are involved, *i.e.*, two evaporator coils in the main brine tank and the direct expansion system in the Freezing Room. The main brine tank with its two evaporator coils is as before, but provision has been made for making the two compressor units, the two condensers, and the three cooling units as interchangeable as possible without making the circuit cross-over system unduly complicated. Fig. 12, which was taken before the delivery and return ammonia valves were set in their insulation shows the by-pass arrangements by which this is effected. Fig. 13 shows (right) the return valves in the final condition.

The main brine tank supplies brine to the coolers of Nos. 3 to 6 rooms, to the main air lock, and to the Freezing Room air lock, by means of the pumps already described (*see* Introduction).

Fig. 14 shows the arrangement of the brine pumps, the brine header (delivery valves), and piping with insulation in the course of completion.

The insulation of the brine pipes consists of compressed cork sheathing, surrounded by granular cork in a wooden casing so that a minimum thickness of 8 inches of cork is provided.

The main brine tank also supplies brine to a divided tank through thermostatically controlled valves (with hand controls in parallel), Fig. 13, the return to the main tank being by gravity. The brine from the two halves of the divided tank is supplied by means of individual pumps to Rooms Nos. 1 and 2. These special brine-supply arrangements in respect of Rooms Nos. 1 and 2 have been devised as a means of investigating ripening technique by providing greater flexibility in the independent control of both temperature and humidity. The large double-coil cooler in No. 4 Room also contributes to greater flexibility along these lines. The use of long distance thermometers, as described in the Introduction has been continued but with only one in Rooms 1, 2, 5 and 6.

In effecting the several changes described above, it will be seen that full use was made of the original components (including the ice-making tank, &c.), the purchase of new equipment being curtailed to the minimum.

In concluding this Section, it may be mentioned that the form of the Engineer's log sheet is such as to yield data of interest both to the biologist and engineer.

Library, Publications and Staff.

While the main College Library is used for all general references, an attempt is being made to assemble in the Station a collection of special literature dealing with the storage of perishable produce.

In so far as the function of this Station includes both the prosecution of fundamental research, and the investigation of problems of immediate practical importance, the publication of results is three-fold, *i.e.*, by means of contributions to scientific journals, by memoirs largely of interest to those engaged in the fruit and vegetable industry, and by articles of general or topical interest contributed to the College Journal.

As presently constituted, the Staff consists of the Officer-in-Charge, a Plant Physiologist and a Biochemist, aided by locally trained assistants. The three engine room operators are under the supervision of the College Engineer.

Acknowledgments.

The Officer-in-Charge takes this opportunity of expressing his sincere thanks to all those who have assisted in the establishment of the Low Temperature Research Station on its present footing: to the Executive Officers of the Colonial Development Fund for the supplementary grants which made this work possible; to Sir Geoffrey Evans, KT., C.I.E.; for his sustained support in all matters relevant to the welfare of the Station; to Dr. F. Kidd and Members of the Staff of the Low Temperature Research Station, Cambridge, for their assistance and advice in technical and scientific matters; to Messrs. J. & E. Hall, Ltd. of Dartford, for their cordial collaboration in discussion of the details of the reconstruction described above; and, not least, to Mr. C. T. Watts and Mr. E. R. Leonard, for their very helpful co-operation at all stages in the planning and execution of the innovations described.

References.

1. Leonard, E. R.—The Storage of Trinidad Citrus Fruits. *Mem. 2, Low Temp. Res. Stat., I.C.T.A.*, 1936.
2. McGuire, L. P.—The Low Temperature Station. *Tropical Agriculture*, VII, 4, 1930.

REVIEWS.

A MANUAL OF TROPICAL SANITATION.

By J. Balfour Kirk, *Bailliere, Tindall & Cox*, London, 1937, pp. 300, price 7*s*. 6*d*.

This handy volume has been written to provide a refresher text book for Sanitary Inspectors, but will also be useful to a wider public.

The scheme of the book has been carefully planned; it begins with chapters on the Cell and on elementary Anatomy and Physiology, and proceeds to deal with the various topics of importance in tropical sanitation.

The style is clear and direct, and the various subjects are treated in a practical and common-sense manner, and throughout emphasis is laid on the importance of the personal factor.

The book, a record evidently of extensive and first hand experience, is a welcome addition to the literature on tropical sanitation, and should have a wide circulation, not only among Sanitary Inspectors, but also among laymen in charge of plantations and labour units.

J. R .D.

PRACTICAL PLANT BREEDING.

By W. J. C. Lawrence, F.L.S., *George Allen & Unwin*, London, 1937, pp. 156, price 5*s*. 6*d*.

The author has tried to give in simple language the scientific background of plant breeding. He has produced a concise handbook which goes far in achieving the purpose for which it was written. The subject matter passes in an orderly way from a consideration of the reproduction of the flower and the technique of breeding, to the laws and mechanism of inheritance, sterility, and the methods and results of plant improvement. In those sections dealing with linkage, polyploidy and incompatibility, the reader may feel that, even with a courageous rejection of technicalities, the difficulties of an attempt to introduce the practical man to modern cytogenetics have not been convincingly overcome. Nevertheless, the book should be stimulating reading to all gardeners, whether by hobby or profession.

K. S. D.

Photo by *Tucker Pictures Production L'd.*

FIG. 13.—View of engine room showing the main brine tank (left) with brine return valves and thermometers; the raised, divided brine tank (centre, right) with brine valve thermostats on side and a brine pump below; and ammonia return valves and circuit diagram (right). Above are the insulated casings to the ammonia and brine piping.

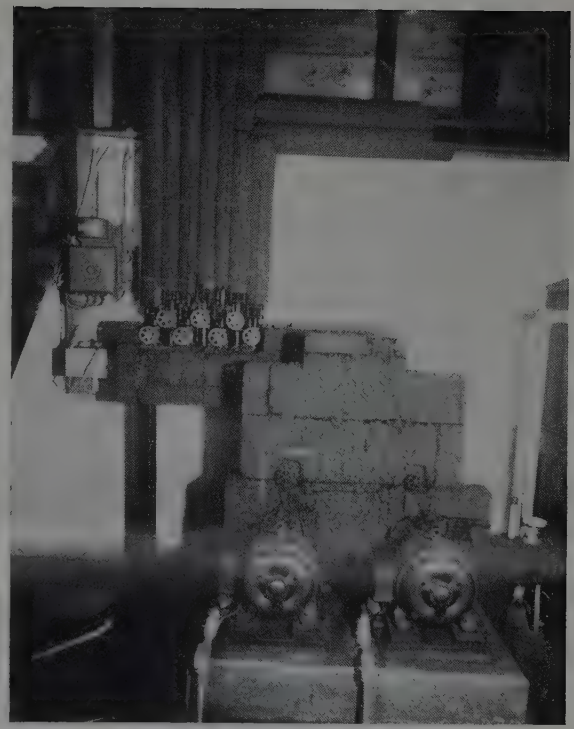

Photo by *Tucker Pictures Production Ltd.*

FIG. 14.—Photograph taken during construction showing main brine tank (right) brine delivery pipe and thermometer (bottom right) brine pump motors (bottom centre) brine delivery header and valves (centre) and brine pipes leading to cooling units (top). The illustration shows the cork slab insulation applied to the brine pumps, and cork sheathing surrounding the brine pipes. The long distance thermometer (centre, left) is also shown.

FIG. 1.—Results of First Mitscherlich Test (*Antigua Calcareous Soil*; *Sudan Grass as Test Plant*). Pots A, B, C; Nitrogen and Potash. Pots. D, E, F; Nitrogen, Potash and Phosphate.

FIG. 2.—Results of Second Mitscherlich Test (*Antigua Calcareous Soil*; *Sudan Grass as Test Plant*). Pots A, B, C; Nitrogen and Potash. Pots D, E, F; Nitrogen, Potash and Phosphate.

THE PHOSPHATE REQUIREMENT OF CALCAREOUS SOIL.

Results of Mitscherlich Pot Tests and Tomato Seedling Tests Applied to a Typical Calcareous Clay Soil from Antigua, B.W.I.

By F. Hardy, D. M. Hanschell and E. H. Amoroso-Centeno (*Analyst*).
(*Imperial College of Tropical Agriculture, Trinidad, B.W.I.*).

(I) Introduction.

Results obtained by the Truog quantitative chemical test for the available phosphate content of a soil generally agree quite closely with field experience and with the data obtained from elaborate manurial experiments, *provided the soil is not an alkaline or calcareous type* (or a highly ferruginous, red type). The mode of occurrence of phosphate in calcareous soils is apparently different from that in most non-calcareous soils, so that the solubility relations of the phosphate component are different. No entirely satisfactory chemical method for accurately assessing the available phosphate status of *calcareous soils* has yet been devised, hence recourse has to be made to biological tests.

The following account presents some results obtained by this means for a calcareous soil, derived from soft Oligocene limestone, occurring in the northern part of the Island of Antigua, B.W.I. (1).

(II) Experimental.

(1) *Description of Soil.*

The soil is a mixed sample representing typical sugar-cane surface soil to six inches depth. It is black in colour, clayey in texture (Index of Texture, 40), granular in structure, highly alkaline in reaction (pH 8.0), and contains a medium-high amount of calcium carbonate (16.6 per cent.). Its organic matter and nitrogen contents are fairly high (3.0 per cent.; 0.16 per cent.), with high C/N ratio (11.0). Its available potash content, according to accepted standards, is very high (347 p.p.m. exchangeable K_2O), and its *apparent* content of available phosphate (Truog method) is medium-high (55 p.p.m. P_2O_5). Its content of total manganese oxide is relatively low (0.13 per cent. MnO), and would be considered inadequate for a fertile calcareous soil.

(2) *Results of Mitscherlich Pot Test* (First Test).*

The standard Mitscherlich method of procedure for determining phosphate status was followed, with Sudan Grass (*Andropogon sorghum* var. *sudanense*) as test-plant (2), (3). Standard Mitscherlich pots, six in number, were used. The soil was diluted with its own volume of pure quartz sand before putting into the pots. Three pots of soil received standard dressings of nitrogen, phosphate and potash manures, and three received only nitrogen and potash. The grass seeds were sown on 27th March, and the mature crops were reaped on 7th June, 1937 (ten weeks' growth). Weights of oven-dry matter are presented in Table I.

Table I—First Experiment.

Pot.	Treatment.	No. of plants per pot.	Yields (Gms. dry matter).		Mean yields.	
			per pot.	*per plant.*	*per pot.*	*per plant.*
A	NK	8	23.5	2.94	19.6	1.83
B	NK	2	1.5	0.75		
C	NK	22	33.7	1.53		
D	NPK	22	97.8	4.44	103.0	5.33
E	NPK	18	111.7	6.20		
F	NPK	18	99.5	5.53		

The available phosphate content of the soil, calculated from these values by the Mitscherlich formula, is only 0.046 g. P_2O_5 per pot, or 0.48 cwt. (54 lb.) P_2O_5 per acre, which, from Mitscherlich's tables (2) is very much too low to satisfy the phosphate requirements of crops. According to Mitscherlich, the lower limit of phosphate adequacy is 1.8 cwt. (202 lb.) P_2O_5 per acre. This is about $3\frac{3}{4}$ times greater than the available phosphate content of the Antiguan calcareous soil, on the basis of the results of this test. The soil's deficit of available phosphate is thus about 148 lb. P_2O_5 per acre, equivalent to 870 lb. superphosphate per acre.

The germination of the seeds in all cases was excellent, but, within six days, the majority of the seedlings in pots A, B and C that received no phosphate additions, died out. Repeated supplying with fresh seed failed to fill all the gaps. Chlorotic symptoms developed in pots D, E and F, when the plants were three feet tall, but the chlorosis was easily cured in four days by spraying the plants with dilute manganese sulphate solutions.

(3) *Conclusions from First Mitscherlich Test.*

Although the Truog test indicated that the soil possessed more than an adequate supply of available phosphate (55 p.p.m.; limit of adequacy provisionally taken as 35 p.p.m.) the Mitscherlich test showed that it contained a very marked insufficiency of available phosphate (at least to satisfy the needs of Sudan Grass), of magnitude equivalent to a dressing of superphosphate manure of about 870 lb. per acre.

* The results of Mitscherlich pot tests and tomato seedling test are taken from an unpublished dissertation submitted by D. M. Hanschell in part fulfilment of the requirements for the Associateship of the Imperial College of Tropical Agriculture, 1936-37.

The appearance of the crops in the first experiment is shown in the reproduced photograph (Fig. I).

The average weights of dry matter produced by a single plant in the phosphate series was 5.33 g., and in the no-phosphate series, 1.83 g., so that about three times as much dry matter per plant was produced by the phosphate-treated calcareous soil as compared with the untreated soil.

(4) *Results of Second Mitscherlich Pot Test.*

The same soils in the same pots were resown with Sudan Grass seed, after stirring and adding a second Mitscherlich basal dressing of nitrogen and potash manures to each of the six pots. No further amounts of phosphate manure were added in any case. The results obtained are presented in Table II.

Table II—Second Experiment.

Pot.	Treatment.	No. of plants per pot.	Yields (Gms. dry matter).		Mean yields.	
			per pot.	*per plant.*	*per pot.*	*per plant.*
A	NK	0	0.0	0.00	5.2	1.05
B	NK	3	4.0	1.33		
C	NK	7	6.5	0.93		
D	NPK	13	22.2	1.71	23.2	1.88
E	NPK	12	21.5	1.79		
F	NPK	12	26.0	2.17		

One culture (A) in the second trial failed to produce any plants at all in spite of repeated resowings. As in the first experiment, the phosphate-treated cultures produced much better and larger plants than those not treated with phosphate, though the yields of the second experiment were considerably lesser in magnitude than those of the first, as was expected. It should be noted that adequate nitrogen and potash were provided by the standard Mitscherlich dressings supplied to each of the pot cultures in these experiments, so that any increase in yield must be attributed solely to the added phosphate.

No phosphate calculations are attempted for the second experiment, since it was not orthodox; the second set of results merely provide qualitative corroboration of the first set. The appearance of the crops in the second experiment is shown in the reproduced photograph (Fig. II).

(5) *Phosphate Status (by Chemical Test) of Pot Soils of the Mitscherlich Tests.*

The Truog test applied to the soil treated with the standard Mitscherlich basal dressings, including phosphate, in the three pots D, E and F., gave values which were about 15 p.p.m. P_2O_5 greater than the values given for the soil not treated with phosphate (pots A, B, C), thus yielding qualitative evidence that the test differentiates between a high and a low phosphate status, even in calcareous soils. The apparent magnitude of this difference in our case is not commensurate, however, with the very great difference in actual yield which the two series of pot cultures produced.

(6) *Results of Tomato Seedling Test.*

Tomato seedlings have been found by Mayer (4) in Germany to furnish a sensitive indicator of phosphate shortage in soils, containing otherwise adequate amounts of nitrogen and potash. The chief symptoms that develop after about 14 days in phosphate-deficient soil are (i) purple coloration of the underleaf surface, and dark green coloration of the upperleaf surface, both for cotyledons and first true leaves, and (ii) upward inclination, acute angle, or adhesion of tips of cotyledons. After two to three months' growth the relative phosphate contents of soils may be compared on a basis of dry weights of plant material produced.

McDonald (5) has successfully applied the tomato seedling test to various Trinidadian cacao soils, none of which, however, was calcareous. Later, he applied the test to certain Antiguan alkaline clay soils (1), representative of types occurring in the Central Plain and the Southern Alluvial areas, but not to calcareous types such as occur in the Northern hilly limestone district.

In conjunction with the Mitscherlich experiments described above, the tomato test has now been applied to typical calcareous Antiguan soil, as follows.

Six cigarette tins were filled with the calcareous soil, and an adequate dressing of superphosphate manure was applied to three of the tins. Ten tomato seeds were sown in each tin, and all but four seedlings were removed on germination. Later, the plants were reduced to one per tin after three weeks' growth.

Typical symptoms of phosphate starvation appeared in the seedlings of the three cultures that received no superphosphate additions, but in none of the others. Weights of plant material were not determined, since the plants of the untreated series soon ceased to grow.

(III) Agricultural Considerations.

(1) *The Peculiar Phosphate Relationships of Alkaline and Calcareous Soils.*

The phosphate relationships of alkaline and calcareous soils have been studied intensively at the Experiment Station of the University of Arizona, U.S.A., since 1926 (6), (7), (8), (9), (10), (11). The main results and conclusions reached by the Arizona workers may be summarised as follows (12):—

(i) Although alkaline and calcareous soils frequently yield large amounts of phosphate to acidic extracting agents customarily employed in chemical soil analysis, and may thus appear to contain abundant available phosphate, field crops grown on these soils may still give marked responses to *soluble* phosphatic manures (though rarely to insoluble phosphatic manures).

(ii) On the other hand, such soils yield water extracts containing only traces of phosphate, indicating that their phosphatic components are very insoluble in weak or mild solvents.

(iii) Alkaline and calcareous soils absorb or combine with large quantities of carbon dioxide produced by plant root respiration or decomposing plant residues, their alkaline components thus quickly removing one of the main natural phosphate-dissolving agents generated by the living plant and by the soil, namely, carbonic acid.

(iv) At alkaline reactions between pH 8.0 and 8.5, phosphate is thought to occur in calcareous soils mainly as insoluble "calcium phosphato-carbonates", and "alumino-phosphates", but these compounds appear to become soluble at soil reactions more alkaline than pH 8.5.

(v) Plant roots seem to be less capable of absorbing phosphate-ion from nutrient water cultures at reactions more alkaline than pH 7.6 than from water cultures having neutral or acidic reactions.

The agricultural procedures recommended by the Arizona investigators for rectifying the unsatisfactory phosphate status of alkaline and calcareous soils are chiefly (i) the application of large dressings of organic manures or compost which, through their decomposition and oxidation, produce large quantities of carbon dioxide, (ii) the use of *soluble* phosphatic mineral manures (such as superphosphate and other acidic phosphates), which may "revert" to available dicalcium phosphate in the soil, but not to the very insoluble and unavailable tricalcium phosphate, under the prevailing highly alkaline conditions.

The solubility of the phosphorus compounds occurring in soils has recently been investigated by Rice Williams (13), who particularly examined their extraction by solutions of sodium hydroxide. Among the commoner soil phosphorus compounds, Rice Williams includes (i) iron and aluminium phosphates, (ii) organic phosphorus compounds, (iii) exchangeable phosphorus in the colloidal clay complex, (iv) the mineral apatite, and (v) other mineral forms of calcium phosphate. Of these, all *except* the apatite type of calcium phosphate appear to be soluble in sodium hydroxide solutions (of concentrations ranging from 0.5 to 20 per cent.) having high pH values. Hence, in alkaline and calcareous soils, it seems likely that the most easily-available phosphorus is present as complex organic phosphorus compounds. The use of ground rock phosphate, apatite, bone meal, bone ash, basic slag, and even guano (all of which are practically insoluble in alkaline solutions) for manuring phosphate-deficient alkaline and calcareous soils would therefore *not* be advisable; instead, phosphorus-containing organic manures should be employed, such as pen manure and compost manure, or soluble, acidic, artificial phosphatic manures, such as superphosphate.

(2) *The Results of Manurial Experiments on Calcareous Soils in the British West Indies.*

An extensive series of comprehensive manurial experiments on sugar-cane, growing in different types of soil occurring in Trinidad, Antigua and St. Kitts, has been conducted in recent years by P. E. Turner and his associates. The earlier results have been presented in numerous articles published in *Tropical Agriculture* since 1930. Among other information, these experiments have clearly demonstrated that, in the case of the Alluvial Clays of the Northern Plain of Trinidad, the diminution in yield due to high liming of soils, even if treated with applications of sulphate of ammonia, may be counteracted by dressings of superphosphate (880 lb. per acre), and that the beneficial effect of potash manure, added together with sulphate of ammonia, appears also to depend on the presence of adequate available phosphate in the soil (14).

In the case of the Limestone Soils of Antigua, the natural occurrence of excess of calcium carbonate was found to counteract the beneficial effects of sulphate of ammonia, applied with or without potash, *except*, when "suitable" phosphatic manures are supplied in addition (15), (16). The suitable phosphatic manures in the Antigua experiments include (*a*) filter-press mud (0.8 per cent. water-soluble phosphate), (*b*) high-grade pen manure, (*c*) well-rotted cane-trash, and (*d*) superphosphate. The quantities of these manures which proved to be advantageous were—(*a*) three tons, (*b*) 12 tons, (*c*) 3-inch layer, and (*d*) 224 lb. per acre of land. It was also found that best results are obtained when the phosphatic manures are applied early in the life of the sugar-cane crop.

Compared with the results of the Mitscherlich test, the dressing of superphosphate manure employed in the Antigua experiments might perhaps be regarded as rather small, but further field experiments have been laid down in 1937* to assess specifically the optimum dressing of superphosphate required for calcareous soil, and further results will be awaited with interest.

(IV) Summary and Conclusions.

(1) Comparison is made between the results of chemical tests of the available phosphate status of a calcareous clay soil and of two biological tests (namely, the Mitscherlich Pot Test and the Tomato Seedling Test), and the results of certain field manurial experiments.

(2) The mode of occurrence of phosphorus compounds in calcareous and alkaline soils is discussed in the light of recent researches carried out in Arizona and elsewhere, which have helped to explain the peculiar phosphate relationships of these soils, and their significance in agriculture.

(3) Since the availability of phosphate appears to be very low in calcareous soils, best results for phosphate manuring are usually obtained with superphosphate and other acidic soluble phosphate manures (rather than insoluble rock phosphates),

* P. E. Turner: private communication.

and with phosphorus-containing organic manures, such as high-grade pen manure, compost, and filter-press mud, applied in appropriately large dressings.

(4) The possible value of preliminary pot tests of the availability of phosphorus compounds in calcareous soils as a guide to large-scale manurial field experiments is indicated.

(V) References.

(1) The Sugar-Cane Soils of Antigua [Studies in West Indian Soils (V)]; F. Hardy, J. A. McDonald and G. Rodriguez, *Imp. Col. of Trop. Agriculture*, 1933, pp. 34.

(2) The Mitscherlich Method of Determining the Nutrient Content of Soils; R. Stewart, *Imp. Bureau Soil Sci.*, Rothamsted, 1932, *Tech. Com.* No. 25, pp. 46.

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THE RUBBER RESEARCH INSTITUTE OF MALAYA.*

THE Rubber Research Institute of Malaya was established and its Board incorporated in 1925 to take over the research and technical advisory work on rubber-production for the whole of Malaya. Up to that time this work had been done by the Department of Agriculture, Straits Settlements and Federated Malay States, and by the research organisations of the Rubber Growers' Association and other bodies. It was not until 1927 that the Institute had collected its full staff and equipment and commenced operations so that with the occupation of its new premises in 1937 it enters into the second decade of its activities.

The purpose of the Institute may be briefly stated as the employment of the sciences for the betterment, in the sense of the economic advancement, of rubber-growing in Malaya. The fulfilment of this purpose involves both research and advisory work. The scope of the former is shown in the following pages, in which the research work of the four Divisions of the Institute, and the work at the Experiment Station, are described.

Much of the experimental work is necessarily carried out in the field, not only at the Institute's Experiment Station, but also on and in co-operation with a large number of estates throughout Malaya. A large addition to the experimental work in the field under the Institute's supervision has been made, under the provisions of the International Rubber Regulation Agreement, whereby new planting to the extent of ½ of one per cent. of the planted acreage is allowed for experimental purpose. An area of 8,000 acres thus became available for Malaya, and this area is now allocated among selected estates, for the conduct of experiments on various important aspects of rubber-cultivation under a wide range of cultural and soil conditions, the experiments being designed by and under the direct supervision of the Institute. The total number of experiments under this scheme is well over 100, individual experiments varying in size from 25 to 150 acres.

The advisory work of the Institute has hitherto been carried out under very difficult conditions, for since the retrenchment of staff which occurred during the slump the Institute has had only one full-time advisory officer. Two more have now been appointed. This will enable a fuller service to be given in the matter of both advisory correspondence and especially advisory visits. Even with the incomplete staff hitherto available, the amount of time devoted to advisory work and to experiments on estates is illustrated by the

* Reprinted from pamphlet on "The Rubber Research Institute of Malaya," August, 1937.

fact that in the first six months of 1937 the number of letters despatched on technical subjects averaged twenty per day, and the number of visits to estates by members of the scientific staff averaged four per day.

The Institute also maintains a Small-Holders' Advisory Service. With the recent appointment of five Asiatic Rubber Instructors, the cadre of 24 such instructors has now been completed, consisting of 16 Malays, 6 Chinese and 2 Indians. These instructors work under the direct supervision of the Agricultural Officers of the Department of Agriculture, but they are employed by, and they look to and are responsible to the Institute for the technical advice which they give. Since the inauguration of this Service in 1934 it has been of ever-increasing value to small-holders, and there is good evidence that the Service is much valued and sought after by them.

The scientific staff consists, in addition to the Director and his personal assistant, of seven botanists, six chemists, three pathologists, four soil chemists, and a statistician, while for the Experiment Station there is a manager, an assistant manager, and a junior assistant, a total of twenty-six; together with the secretary, clerical staff, laboratory assistants and attendants, a clerk of works and assistant, and artisans and labourers, and a labour force at the Experiment Station.

The income of the Institute, which apart from any profits incidental to its own activities, is provided by the rubber growers of all Malaya (*i.e.* Straits Settlements, Federated Malay States, and other Malay States), is secured by a resolution of the Federal Council, and corresponding arrangements in the Straits Settlements and in the other Malay States, whereby it is entitled to the proceeds of an additional export duty of 10 cents per picul of rubber exported. Since the introduction of Rubber Regulation the mode of collection of the monies concerned has been modified so that the necessary annual contribution is received from the Malayan Rubber Fund. The estimated annual expenditure of the Institute for 1937 is $647,079, of which the contribution from the Malayan Rubber Fund is $597,956. This, together with a separate contribution from Brunei, represents 0.054 cents per lb., or 7.24 cents per picul, of the exportable quota of Malaya for 1937. Assuming an average price of rubber for the whole year of 36 cents per lb., the annual cost of the Institute to the industry represents about 0.15 per cent. of the price which it is receiving for its product.

The Constitution and Governance of the Institute are laid down by Enactment (cap. 108) of the Federated Malay States and corresponding Ordinance or Enactments for the other Malayan administrations. Two of its members are appointed by the High Commissioner to represent the interests of small-holders; and five are appointed by the High Commissioner for a panel of twelve persons nominated by the Rubber Growers' Association, the United Planting Association of Malaya, and the Malayan Estate Owners' Association jointly. Planting interests are thus fully represented on the Board, by seven out of its ten members.

The Institute works in collaboration, so far as possible, with the research organisations of other rubber-producing countries in the East, and in particular with the Rubber Research Scheme of Ceylon. That Scheme, and the Rubber Research Institute of Malaya, support financially and work in close touch with, the London Advisory Committee for Rubber Research (Ceylon and Malaya) and with its scientific staff.

The Institute was housed temporarily in a building off Damansara Road, Kuala Lumpur, but the volume of work developed so rapidly that it outgrew the building and extensions and a larger and permanent home became necessary.

The buildings which it now occupies at 3rd Mile, Ampang Road, Kuala Lumpur, were formally opened by His Excellency the Governor of the Straits Settlements and High Commissioner for the Malay States, Sir Thomas Whitelegge Shenton Thomas, G.C.M.G., O.B.E., on 19th May, 1937.

The lay-out consists of five separate single-storied blocks ranged round an inner courtyard and connected by covered ways, together with various out-buildings. On the southern side the Administration Block occupies the whole frontage; on the eastern side there are two blocks, occupied by respectively the Botanical Division and the Pathological Division; at the northern side of the quadrangle there are the Soils Division and part of the Chemical Division, which also occupies the whole of the western side.

The cost of the buildings, excluding their contents, was $265,000, the whole of which has been provided from the Institute's accumulated reserves.

Botanical Division.

The Botanical Division is chiefly concerned with the study of the rubber tree and the investigation of the many factors which affect the production of latex.

The development of trees of increased yielding-capacity by selection and breeding, in combination with improved methods of propagation, forms one of the most important branches of the work of the Division. Propagation of high-yielding trees by budding, and the study of clones grown under different conditions, have advanced rapidly in recent years. Now, results of great practical importance are also being obtained from the work on breeding and the study of families of seedlings derived from high-yielding parent clones. This work is conducted chiefly on the Institute's Experiment Station and has been extended by means of large-scale experiments on estates in all parts of Malaya, whilst complementary to it are laboratory investigations of the structure of the tree with particular reference to the process of latex-production.

Tapping methods form the next most important subject of research. Experiments designed to study the effect of variation in the methods of tapping on yield and rate of bark-renewal are being carried out on fully mature seedling trees and on budded trees of many different clones. The study of the tapping of budded trees has shown that it will be necessary to modify considerably the systems of tapping which have so far proved satisfactory on seedling trees, in order to obtain the best results from buddings.

The effects of environmental conditions on growth and yield are also being studied, in close collaboration with the Soils Division. The ecological study of rubber areas and the study of methods of cultivation involving the use of natural covers of indigenous plants are in progress. A further important aspect of this work is the study of the growth and yield-capacity of different clones on different types of soil. This work is of particular importance in relation to the selection of the best type of planting material for use in replanting.

Up to the present time the major botanical problems have been studied principally by means of field experiments. Recent additions to the staff of the Division have made it possible to start further work on the more fundamental aspects of the problems of latex-production, such as the influence of nutrition and the effects of different essential elements of plant-food on growth and yield.

Chemical Division.

The Chemical Division concerns itself with the preparation and properties of rubber in its commercial forms of smoked sheet, crepe, preserved latex and concentrated latex; the development of new and modified forms of rubber; and the chemical and physical nature of the non-rubber constituents of latex.

Rubber-growers wish to produce rubber by the cheapest and most efficient methods, and because smoked sheet is the chief product most research has been directed to it. The Institute has been closely connected with most of the recent improvements in factory lay-out-machinery, and smoke-houses. Close attention is still being paid to the drying and smoking of rubber with the object of developing still more efficient types of smoke-houses.

Because the quality of rubber varies from estate to estate, and at different times on the same estate, in hardness, rate of vulcanisation, and resistance to perishing after vulcanisation, work is directed towards discovering methods of factory procedure which will reduce or eliminate this variability, which causes considerable trouble to manufacturers. Preserved latex also shows variability in such properties as stability, film strength, viscosity, surface tension, colour, and odour. Research which aims at finding means of ensuring uniformity in physical properties together with freedom from undesirable colour and odour is in progress.

Concentration of latex by creaming, centrifuging, evaporation, and filtration is being given considerable attention. Some new creaming agents have been found and further research will reveal others. Means for improving the efficiency of existing creaming agents are also studied. Research has been undertaken on the efficiency of different centrifuges, and on means of improving their efficiency by pre-treatment of the latex. Work is being done on concentration by evaporation in a machine designed by the scientific staff of the London Advisory Committee. Studies on direct concentration by filtration, and concentration by filtration after partial concentration by other means, have recently been commenced. New preservatives for latex are also being investigated.

Specialised work, which at the moment has little or no direct bearing on estate practice but which might have great possibilities in the future, includes the preparation of soft rubbers and of rubbers with low water-absorption properties, and the study of the non-rubber constituents of latex. The last named is an investigation into the fundamental nature of rubber, and will eventually yield results of prime importance.

Pathological Division.

This Division studies the diseases and pests of the rubber tree, and the methods of controlling or preventing these either by direct attack upon the organism concerned or by methods involving some change in cultivation or routine estate practice.

Investigations are proceeding on the distribution, propagation and mode of attack of the root-disease fungi, *Fomes lignosus*, *Fomes noxius* and *Ganoderma pseudoferreum*, which cause White, Brown and Red Root Diseases respectively. These are being studied with a view to finding improved methods for their control and eventual eradication, particularly in young areas. Along with these investigations the well-known disease, Collar Rot, caused by the fungus *Ustulina zonata*, is also studied.

Diseases of the tapping panel such as Mouldy Rot, *Ceratostomella* sp., Black Stripe and Patch Canker, *Phytophthora* sp., White Fan Blight, Sunscorch and *Fusarium* Dieback call for frequent attention. In connection with Mouldy Rot this Division is responsible for carrying out the official tests of proprietary fungicides. Of the stem- and leaf-diseases of the rubber tree, the leaf Mildew Fungus, *Oidium Heveae*, has received considerable attention of late. Investigations into the life-history and climatological preferences of the fungus and the control of the disease by sulphur-dusting are proceeding. The adoption of woody bush covers and forest growths for soil-conservation purposes has necessitated an enquiry into the susceptibility of the rubber tree to the different varieties of the Pink Disease fungus, *Corticium salmonocolor*, isolated from the disease on various

species of cover-plants. Evidence of the susceptibility of various clones of bud-grafted rubber trees to attack by leaf-diseases is being accumulated, and is recorded for future study.

The Division is also concerned with work on the microbiology of soils, of organic manures, and of latex (the last-named in conjunction with the Chemical Division). In co-operation with the Soils Division the nodule bacteria of leguminous cover-plants are studied in connection with the effect of covers on the fertility of soils.

Of the animal pests which are now receiving close attention, the Cockchafer or "white grub" pest of roots, Termites or "White Ants", and the Thrips pest of leaves are the most important. Other pests such as beetles, cutworms and other caterpillars, Coccid bugs, and mites are given attention as occasion demands.

Soils Division.

As its name implies, the Soils Division of the Institute investigates the medium in which the rubber tree grows. All aspects of soil work are studied in so far as they have a bearing on the cultivation of rubber.

In the laboratory itself the chief work is the analysis of soil samples taken from all those parts of Malaya where the rubber tree is grown. When a sample is taken a description of the rubber growing on that land is recorded. When the analyses—of which there are many thousands to be done—are complete, it will be possible to classify soil-types throughout the country in the order of their ability to grow good rubber. In conjunction with the information now being gained from manuring experiments, this classification of rubber-growing soils will be most valuable, especially in regard to future planting on new land.

Other work which is being done in the laboratory includes research on the phosphate-status of Malayan soils; nitrogen-transformation in soils; the effects of manures, cover-plants, and cultivation on the composition of soils; and the value of chemical analyses of the leaves as a means of finding out what plant-food the rubber tree needs. In addition, pot-culture work has recently been started to investigate the soil factors affecting nitrogen-fixation by leguminous covers; the effect of phosphate on the early growth of rubber on different soil-types; and the symptoms of plant-food deficiencies in young rubber plants.

In the field, the Soils Division has planned and is controlling a large number of experiments on the manuring of rubber of all ages growing on many types of land; and on the effects of many kinds of covers, both cultivated leguminous covers and natural "forestry" plants, on the growth of rubber. Some of these experiments are being carried out on the Institute's Experiment Station and others are being done on estates whose owners have agreed to co-operate with the Institute for the number of years considered necessary. A most important class of experiments includes those being laid down in conjunction with the Botanical Division on estates where permission has been granted to do experimental planting on new land. The field experiments commenced in 1937 alone cover a total area of well over 2,000 acres, and most of them will continue for several years.

Experiment Station.

The Experiment Station of the Rubber Research Institute is in Sungei Buloh Forest Reserve, four miles from the village and railway station of Sungei Buloh, and seventeen miles by road from Kuala Lumpur.

Felling of the jungle was started in 1928, and most of the planting was done during the next two or three years. The area opened up to date (July 1937) is 1,057 acres, of which 506 acres are in tapping. There is still some reserve land, and the area available for experimental work is altogether 1,351 acres. The central building site covers 70 acres. It has on it staff bungalows, guest-house for visitors, coolie-lines, office, factory, smoke-houses, and sundry other buildings, all within easy reach of each other.

The experiments in progress have been designed by Research Officers of the Institute, and the field work in connection with them is supervised by the Manager of the Experiment Station. They cover all aspects of rubber-production. The earlier ones were concerned chiefly with such matters as bud-grafting, seed-selection, manuring, the cultivation of covers, and the diseases of young rubber trees. During the last two or three years experiments on different methods of planting have been started. More recently, since the Station came into production, experiments on the preparation of raw rubber have been carried out, especially in regard to the design and working of smoke-houses.

As an indication of the work involved in doing field experiments, it might be mentioned that in many of them the yield from each tree must be recorded. This is done by coagulating each day's latex in the tapping cup, and weighing the resulting lumps of coagulated rubber at suitable intervals. At present, 70 per cent. of the crop of the Experiment Station consists of cup lumps. However, although such extensive experimental work is being done, the Station is in other respects run on regular estate lines and the history and costs records may be inspected by any interested visitor.

During one year (1936) nearly 600 visitors came to the Station. They were mostly Malayan planters, but there were also many non-planters and foreign visitors.

ACKNOWLEDGMENT.

We have pleasure in acknowledging the presentation of a Lime Spreader, for use on the College Farm, by Messrs. T. Geddes Grant & Co., Ltd., Trinidad. This gift is much appreciated.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Hybridization in and with the Genus Saccharum.—*T. S. Venkatraman.*

In his presidential address, the author outlines the scientific and economic aspects of the crossing of the ordinary sugar-cane with wild genera and species, and even with the bamboo. It is a complicated task beset with difficulties, which still requires much patient work for final solution. The peculiarities of *Saccharum* hybrids are many and varied. One is that, when sugar-cane is grown from seed, there is great dissimilarity in all characters; root system, stem, leaves and sugar content—from which it is difficult to make satisfactory recombinations. The hybrids show a general absence of well-defined segregation of characters. Another peculiar characteristic of interspecific sugar-cane hybrids is a fairly general absence of sterility. Even in the case of intergeneric hybrids, it has been found that, though the "F" plants do exhibit sterility the first year, some of them produce fertile pollen after further vegetative propagation, and set seed freely.—(*Facts About Sugar*, Vol. XXXIII, No. 5, p. 37, 1938.)

* * *

Improved Methods of Liming.—*G. MacLean.*

The author describes a modern installation for liming cane-juice in a Cuban mill, which is especially designed to stabilize the pH and to protect the juice against over-liming. The flow of juice is continuous, and the liming is done in *two stages*, before and after heating; in the first stage, the most favourable pH for the heating operation can be chosen, and in the second, the pH most favourable for clarification in the Dorrs. A constant pH, in spite of variable flow of the juice, is maintained by "Micromax" pH controllers; the reaction time of these controllers is 40 seconds, so that changes in rate of liming are promptly adjusted. Thorough mixing of the milk of lime with the raw juice is assured by a high speed Turbo-mixer, so that local over-liming cannot occur over a period of time greater than a tenth of a second. This instantaneous dispersion, or "flash mixing", assures that the pH meter reading can be counted on for accurate control.—(*Facts About Sugar*, Vol. XXXIII, No. 5, p. 35, 1938.)

* * *

Migration of Potassium in Sugar Cane Leaves.—*By M. Kenjo.*

Separate leaves of individual cane stalks were individually analysed, beginning at the lower end of the stalk and proceeding towards the top. In this way it was found that the amount of potassium in cane leaves is the greater, the higher up the leaf is on the stalk; the youngest leaves always contain the most potassium. This indicates that as new leaves develop they may draw to themselves the potassium contained in the lower leaves, *i.e.*, the potassium migrates from below upward in successive stages.

The extent to which the old leaves are deprived of their potassium by the young ones depends on the supply of available potash in the soil. If soil potash is deficient, the young leaves make heavy draughts on the potassium in the old ones with the result that the latter may contain very little, while the young leaves are found to contain about as much as the corresponding leaves of plants grown in soils not deficient in potash.—(*Int. Sugar Journal*, Vol. XL, No. 469, p. 33, 1938.)

* * *

Filtrability of Co. 213 Sulphitation Scums.—*By S. V. Ramayya.*

By reason of its high yield resistance to drought, frost, pests and diseases, the cultivation of Co. 213 cane is spreading rapidly in some districts of Upper India. Nevertheless, under dry growing conditions, it develops highly refractory juices, especially at the filtering station, which seems to nullify its supposed advantage of drought resistance. Filtration difficulties are more evident in proportion to the efficiency of the juice strainers, which remove bagacillo that might otherwise function as a filter-aid. The author made some laboratory experiments, using bagasse carbon obtained by charring bagasse in the open air until the ashing stage just begins. The carbon thus obtained is thoroughly washed to remove soluble matter, and the product is found to have excellent properties as a filter-aid. Nevertheless, adequate irrigation and the use of phosphate fertilizer decrease filtration troubles in the factory.—(*Facts About Sugar*, Vol. 33, No. 6, p. 34, 1938.

* * *

Applications of Luminescence in the Sugar Factory.—*By M. Deribere.*

Luminescence is a term applied to the ability of certain substances to emit light without the evolution of heat. It may be excited in various ways, including irradiation by means of X-rays, ultra violet rays, &c. One variety of luminescence, called fluorescence, is produced by the reflection of invisible light rays of short wave length in such a way that the wave lengths are widened so as to appear in the visible part of the spectrum; this form of photo-luminescence has some valuable applications. The presence of certain sugars can be detected when a solution of the sugar is examined in Wood's apparatus. Invert sugar in a sucrose solution can be recognized, because the sky-blue fluorescence of sucrose is changed to a milky hue shot with yellow. Impurities, antiseptics and colouring matters can be detected by their characteristic fluorescences, and in certain definite cases this method of investigation may prove valuable.—(*Facts About Sugar*, Vol. 33, No. 6, pp. 34-5, 1938.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Heart-Rot of Sugar Beet and Boron Deficiency.

Sugar beet is subject to a severe disease the symptoms of which are a rotting of portions of the root, and frequently the death of the terminal bud. It is now recognised that this malady is occasioned by a deficiency of boron in the soil. Drs. Winifred E. Brenchley and D. J. Watson have made a study of the effect of this element upon the second year's growth of infected sugar beet (*Ann. App. Biol.* 24, 3, 494-503, Aug., 1937). Diseased plants from the field were transferred to sand cultures, some of which contained the deficient element in the form of boric acid. Growth made in the absence of boric acid was uniformly diseased, but the addition of this substance in moderate amount (0.25 gm. per 25 lb. of sand) invariably corrected the trouble. Application of a double amount of boric acid, however, had a somewhat toxic effect.—(*Nature*, Vol. 141, No. 3560, p. 167, 1938.)

* * *

Soil Erosion in U.S.A.

It has been reported that 590 millions of acres of land, representing 30 per cent. of the total area of the United States of America, have been subjected to sheet erosion, resulting in the loss of nearly three-quarters of the surface soil. Already, 115 millions of acres have been practically destroyed for agricultural purposes by gullying. The following quantities indicate the enormous annual losses of plant nutrients that this widespread erosion has entailed: Nitrogen, 11 millions of tons; phosphorus, 13; potassium, 29; calcium, 51; sulphur, 10.5; organic matter, 170 millions of tons.

So serious has the problem become in U.S.A., that the Government has established a Soil Conservation Service, whose cost runs into millions of dollars.—(Abstracted from "The Dissipation of Natural Resources" by P. H. V. Fielder, New Zealand Section of the Institute of Chemistry of Great Britain and Scotland, published in the Institute's Journal for April, 1938, pp. 168-180.)

* * *

Composition of Canes.—*By C. A. Fort and R. L. Holmes.*

On the basis of crusher juice analyses, it has been recognized that when conditions of growth are equal, the different varieties of cane contain the various essential plant nutrients in characteristically different degrees. The present study deals with the analysis of the whole mill cane and the associated green tops. The material used consisted of duplicate composited field samples of Co.281 and Co.290 taken from experimental plots; blades removed in stripping the cane were not considered, and calculations were made on the basis of an assumed yield of 20 tons per acre for Co.281 and 30 tons per acre for Co.290. When certain constituents of the cane are calculated to lb. per ton of mill cane, the figures shown in the accompanying table (below) are obtained.

Inspection of the two bottom rows of figures in the table shows that the percentage content of nitrogen, phosphorus and lime in Co.290 is less than in Co.281, whereas both contain about the same percentage of potash, magnesia, silica and total salts. But when it is considered that Co.290 yields 30 tons per acre while Co.281 yields 20 tons, it is found that Co.290 actually consumes a greater weight of mineral plant nutrients than Co.281. The former variety will evidently deplete the soil of the elements of fertility at a faster rate than the latter, as indicated by these figures:—

	Nitrogen as $(NH_4)_2SO_4$	Phosphorus as $CaHPO_4$	Potash as K_2SO_4.	Sum
	lb.	lb.	lb.	lb.
Co.281	238	82	198	518
Co.290	263	95	344	702

Nearly two-thirds of the 51 to 56 lb. of nitrogen contained in an acre of cane are in the tops. This is equivalent to 160 lb. ammonium sulphate per acre, and represents the amount which could be saved if suitable economical means could be devised for composting or mechanically disintegrating cane-trash so that it can be properly mixed in the soil from which it was derived. The better distribution of the defecation muds would practically return all of the phosphorus of the mill cane to the soil, as well as approximately half of the nitrogen of the cane juice, or roughly, one-sixth of the amount of the mill cane.—(*Int. Sugar Journ.*, Vol. XL, No. 473, 1938.)

	Nitrogen (N)	Phosphorus (P_2O_5)	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Silica (SiO_2)	Total Salts (Approximate)
Tops, Co.281	1.59	0.94	4.25	0.82	0.40	7.78	13.62
Tops, Co.290	1.24	0.51	3.79	0.67	0.39	9.13	11.67
Mill Cane, Co.281	0.94	2.14	5.34	0.84	0.86	5.60	16.00
Mill Cane, Co.290	0.62	1.66	6.20	0.54	0.64	4.20	17.00
Total for Co.281	2.53	3.08	9.59	1.66	1.04	13.38	29.62
Total for Co.290	1.86	2.17	9.99	1.21	1.03	13.33	28.67

TREND OF THE MARKETS.

[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.)

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
26th May ..	5	0	8	9
2nd June ..	5	1½	8	10½
9th June ..	5	1½	8	11¾
16th June ..	5	3	9	0
23rd June ..	5	1½	8	10½
30th June ..	5	0	8	9
7th July ..	5	0	8	9¾
14th July ..	4	10	9	3
(*15th July*, 1937) ..	6	7½	10	4½

At a meeting of the International Sugar Conference in London a deadlock appeared to have been reached on 7th July. There is still an apparent production surplus of about 187,000 tons above world requirements but the countries participating in the Conference were adamant against any further quota reductions. Signs of some relief in the European political situation and of improvement in the economic situation in America may lead to some expansion in consumption in the "free market."

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	Pence per lb.
25th May	5 3-8
1st June	5 9-16
8th June	5 11-16
15th June	5 5-16
22nd June	6 5-16
29th June	6 7-8
6th July	7 1-4
13th July	7 3-8
(*14th July*, 1937)	9 3-16

World stocks at the end of May amounted to 546,825 tons, a reduction of 17,251 tons compared with a month previously. It is considered unlikely that there will be any increase in world stocks at the end of June and with shipments subsequently at 45 per cent. of Basic Quotas it appears certain that there will be a steady decline in stocks. Prices have advanced and the tone is firm.

* * *

BANANAS.—Prices have remained unchanged at £19 15*s.* per ton delivered London and £19 10*s.* nearest station Provinces for Jamaicas and £16 London and £17 Provinces for Brazilians. Demand has improved and a fair trade has resulted.

COCOA.—The reason for the recent rise in prices is principally due to a better feeling on the New York Stock Exchange and the consequent reaction on the New York cocoa market, but demand from Europe is still very slow. Good fermented Accra new crop is quoted at 22*s.* and locally $5.50 per fanega is paid for Plantation cocoa.—(*By courtesy of The Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian Giza 7.*	*F.G.F. Sakel.*
27th May ..	4.46	6.78	7.38
3rd June ..	4.43	6.74	7.34
10th June ..	4.54	6.66	7.26
17th June ..	4.69	6.83	7.43
24th June ..	4.83	7.15	7.75
1st July ..	4.96	—	—
8th July ..	5.19	—	—
15th July ..	4.89	—	—
(*16th July* 1937)..	6.85	—	10.05

Reports up to 25th June state that the market has been quiet. Exports from Great Britain of yarn and piece goods during the first five months of 1938 show a reduction of 25 per cent. in the corresponding period for 1937. Exports of cloth are smaller than any recorded during the past 86 years. The Sea Island market has been neglected, sales being confined to a few bales of Leeward at 1*s.* 7*d.* per lb.

* * *

GRAPEFRUIT.—At 30th May small quantities of seeded Jamaican fruit were selling at from 7*s.* 6*d.* to 10*s.* 9*d.* per case. Trinidad fruit was reported to be of good quality and selling at 13*s.* to 16*s.* per case. Fair stocks of Palestine fruit were on hand fetching 12*s.* to 13*s.* for best marks and 11*s.* to 12*s.* per case for ordinary marks.

* * *

LIME PRODUCTS. *Lime Oil.*—Handpressed is very slow of sale and nominally valued at 32*s.* 6*d.* per lb. It is still not possible to report any improvement in the position on distilled. *Lime Juice.*—There is no demand for Concentrated and Raw is quoted nominally at 1*s.* 9*d.* to 2*s.* 3*d.* according to quality.—(*West India Committee Circular*, 16th June.)

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